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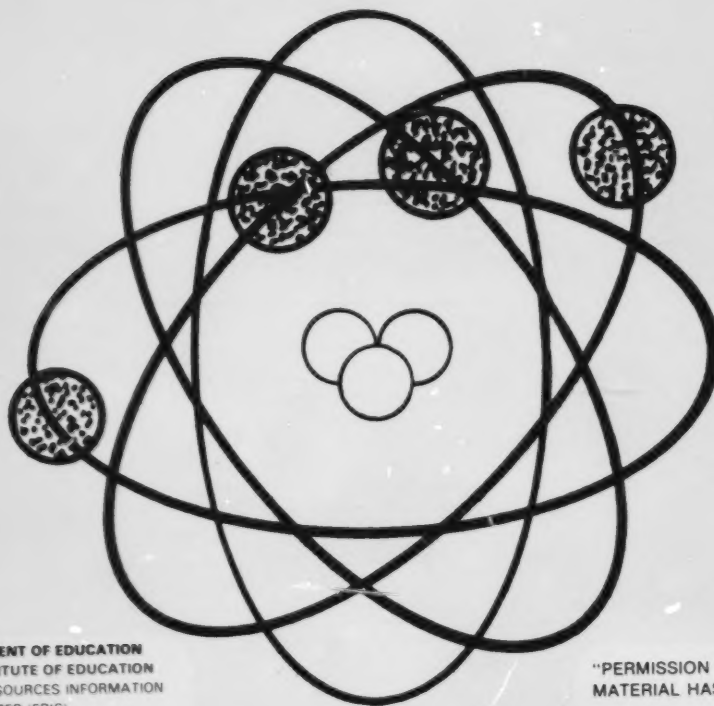
ABSTRACT

This Physics Laboratory Project Book, assembled through a survey of science instructors in vocational-technical schools in Connecticut, is an extension of the Chemistry-Materials Laboratory Project Book (see note) and is intended to meet a variety of needs. It can serve as an idea book, with the instructor taking from it as needed and adding or substituting material related to class interests; as a guide book for starting or upgrading a laboratory program; or as a laboratory workbook for students. Projects in the book are related to various trades or vocational areas. Some of the laboratories are totally oriented toward physics. Some may be very basic and general in nature and may apply to all students and trades; others are more specific and apply only to selected students and trades. Unlike the Chemistry-Materials laboratories, not all exercises here require the use of safety equipment. The first four sections of this project book are directed toward the instructor, and contain an introduction, suggestions for having a successful laboratory exercise and for managing laboratory materials, and a suggested laboratory report format. The following six sections provide materials for student use, and are organized into 82 laboratory experiences. The units cover laboratory orientation, mechanics, heat, sound, light, and electricity. Each laboratory experience contains an explanation of its purpose, materials required, information, procedures, and notes for the instructor. Charts and diagrams are included where needed. (KC)

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PHYSICS LABORATORY PROJECT BOOK



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PHYSICS LABORATORY PROJECT BOOK

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INTRODUCTION

This Physics Laboratory Project Book is an extension of work which was initiated with the development of the Chemistry-Materials Laboratory Project Book. Both were the outgrowth of a survey of related science instructors in our Vocational-Technical Schools. It is by no means total and complete. Additions and changes will be obvious and necessary as the material is utilized by the instructors.

This Laboratory Project Book is designed to meet a variety of needs. It can serve as

1. An IDEA BOOK (the instructor may add or delete material and prepare a lab based on students taught, trades represented, and own background and experience).
2. A GUIDE BOOK (the instructor may be assisted in starting or upgrading a lab program).
3. A LAB BOOK (if satisfactory, the material may be used as a lab workbook).

One major objective when preparing this Project Book was to accumulate a number of lab projects related to various trade or vocational areas. It is obvious that it may contain more lab projects than time allows to complete. It is up to the instructor, then, to plan the lab activities based on the students he/she has.

Some of the labs are totally oriented toward physics. They may be very basic and general in nature and may apply to all students and trade areas. Others are more specific and apply only to selected students and trades. Again, the discretion is left to the instructor to determine which are to be used.

The following are the goals for the Physics Laboratory Project Book.

1. To develop skills in the use of laboratory equipment and apparatus.
2. To provide motivation and develop an interest in physics.
3. To develop responsibility and dependability.
4. To develop habits of sound and thorough record-keeping.
5. To develop an orderly approach to the solution of problems.
6. To provide a relationship of physics to the various trade and vocational areas.
7. To discover new areas of interest and experience.

The following are specific activities for the student in the Physics Laboratory Project Book.

1. Read instructions
2. Follow procedures
3. Set up various apparatus
4. Use various apparatus and equipment
5. Make observations
6. Gather and record data
7. Read instruments
8. Organize data
9. Analyze data
10. Prepare charts, graphs, and diagrams
11. Draw conclusions
12. Communicate results
13. Clean apparatus
14. Practice safety

Unlike the Chemistry-Materials Labs, not all lab exercises here require the use of safety equipment. However, where required, safety equipment (such as aprons, eyeshields, etc.) should be used and safe work habits should be demanded.

The instructor may wish to refer to the Chemistry-Materials Laboratory Project Book for additional ideas. Some lab experiences in that book are also applicable to physics.

A note of explanation--

One of the considerations in preparing this Laboratory Project Book is that of permitting future adjustments or changes. As the material is used by instructors, it may be found that improvements are necessary. Additions or deletions may be a requirement. For this reason, the lab exercises were not numbered, nor were the pages sequentially numbered. The exercises were identified by title and so listed in the table of contents. In the future, should changes be needed, new material can simply be inserted or old material can be removed. The only change, then, would be to update the listing in the Table of Contents.

SUGGESTIONS FOR HAVING A SUCCESSFUL LAB EXERCISE

The cardinal rule for having a successful lab exercise is "BE PREPARED". This applies to the instructor as well as the students. Preparation covers a large area, a variety of items, but if any little portion of it is omitted confusion and frustration may result and the exercise will be a dismal failure.

Here are some suggestions which an instructor might find helpful to assure success:

The instructor should establish definite rules and requirements related to the organization, administration and operation of the laboratory. These should include student conduct and behavior, safety, lab cleanliness, material organization, etc. The rules should be strictly enforced.

The instructor should be familiar with each lab exercise. The instructor should know how long it should take to perform the exercise, where the problem areas are and what the results should be. When in doubt, the lab exercise should be tested or performed by the instructor beforehand.

The instructor should review the lab exercise with the students in advance of the actual performance. Safety notes and problem areas should be specifically identified. The location of various materials for that particular exercise should be specified. Group assignments should be made in advance of the exercise.

The instructor should be certain that all materials, regardless how small, are available before the start of the actual lab exercise. There should be sufficient quantities to insure completion of the lab.

The instructor should be extremely careful in selecting lab exercises. The exercises should be meaningful and enjoyable to the student. If the lab is eagerly received by the students, the task of administration of performance will be an easy one for the instructor.

The instructor should adopt an adequate planning method. It should include long-range plans for future lab work (it is a little too late to hunt for non-existent materials and supplies the day before the lab). It should also include a disaster plan for a current lab exercise (even with the best of preparation a lab exercise can often fail--have an idea for salvaging what is left, or have an alternative).

The instructor should develop communications with the various shop or trade areas. More often than not, what is done in the science class or in the lab can be linked to what is done in shop or discussed in theory. The shops can become an excellent source for ideas and often a source for certain materials.

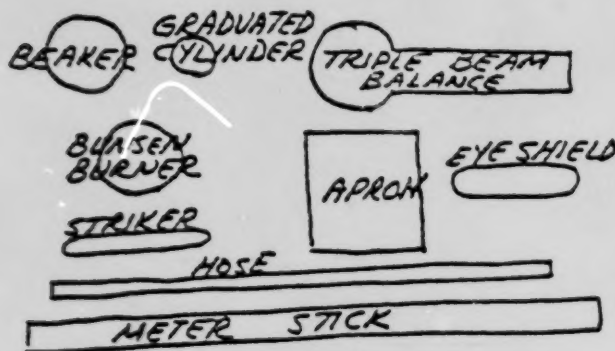
SUGGESTIONS FOR MANAGING LABORATORY MATERIALS

There are many ways to insure that proper materials are available to perform a lab exercise; and, just as important, that these materials are accounted for after the lab. The appropriate method will depend upon a number of variables including available facilities, size of lab group, time available, lab exercise attempted, equipment and supplies available, etc. The following are suggestions that an instructor might find helpful in managing the materials for a lab exercise. Keep in mind that responsibility for management can be shared with the students.

(For the sake of discussion it is assumed that a particular lab exercise requires the following materials: bunsen burner with hose, striker, apron, eyeshield, triple beam balance, meter stick, beaker, graduated cylinder).

ALTERNATIVE "A"

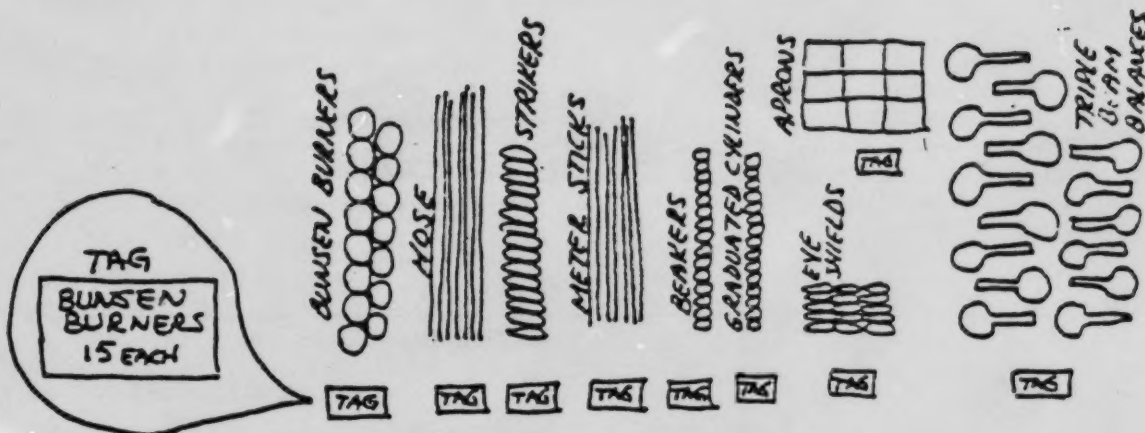
The instructor has all the material placed at each lab station in advance of the lab exercise, following a definite layout. For example:



Every lab station has exactly the same set-up at the outset. Each student is given the layout diagram, either on the chalkboard or on the lab sheet. When the lab exercise is completed and the students clean up, the materials should be replaced as indicated by the diagram. This method gives the instructor the advantage of seeing that every group has what it needs at the start of the lab and returns it at the conclusion. The instructor can visually inspect each station and determine if something is missing. Another advantage of this method is that it avoids confusion at the start of the lab exercise when students rush around to get materials to their lab stations.

ALTERNATIVE "B"

The instructor has all the materials neatly arranged in one location prior to the start of the lab. A tag is placed for each item, along with the quantity, near the item. The students all go to one location to get the materials to start the exercise. At the conclusion, the material is neatly returned to the proper location and an inspection can be made. The instructor could assign a student to make the check for order and accountability.



Materials can also be kept in marked trays, bins or tubs when using this method. For example, one tray could contain the bunsen burner, another the strikers, etc. The advantage of this method is that the materials are all kept in one location. This also creates the disadvantage of students all rushing to the same location to secure or return the materials.

ALTERNATIVE "C"

If the lab is equipped with drawers or lockers at each lab station, the management of material could combine the best of the two alternatives previously mentioned.

One approach could be to always have a basic set-up at each station at all times. The drawer or locker would always contain, let's say, a bunsen burner with hose, a striker, a beam balance, an apron and an eyeshield. The other necessary material for that particular lab exercise would be placed in one location for use in that exercise (as discussed in alternative B).

Another approach could be to store particular materials in the drawer or locker at an individual lab station. For example, all aprons are stored at station 1, all eyeshields at station 2, all burners and hoses at station 3, and so on. At the conclusion of the exercise, all materials are returned to their proper location. The student assigned to that particular station is made responsible for the orderly storage and accounting of the materials there.

ALTERNATIVE "D"

Sometimes there is a problem of not having enough material for each individual lab station or group. This can be overcome in a number of ways depending on the nature of the lab.

One easy solution is to make the lab exercise a demonstration type where the instructor performs the lab making sure to use student assistance. Or, students themselves provide the demonstration.

Another method is to set up special work stations within the lab. The students would do the bulk of their work at their normal lab stations and use the special work station only when required. For example, if there were not enough beam balances for each individual station or group, those that were available could be placed at special work stations. The students would perform their exercise at their normal station and when they needed the use of the balance, they would go to the available special work station.

Still another solution might be to have a series of labs performed on a rotating basis. Depending on the type of lab, the rotation can be done during the lab period itself or it can be done each time the group meets for lab. For example, if each group had to run a quick test on a sample of material (but there wasn't enough material for each individual group), a sample of different materials could be placed at each station. When a test was completed at one station, on command, the students would move to the next station for the next test, etc. This would continue until all tests were made. On the other hand, if each exercise was to take the entire lab period, then the groups could start on different lab exercises and change the next time they meet. This again would be continued until all exercises are completed.

A SUGGESTED FORMAL LAB REPORT FORMAT

NAME: _____

CLASS: _____

TRADE: _____

LAB REPORT NO. _____

"TITLE OF LAB OR EXPERIMENT"

OBJECTIVE(S):

What the purpose of the lab or experiment is; what results are anticipated; or what is to be proven. Should be concise.

DIAGRAM AND/OR LIST OF MATERIALS:

A simple, but complete, diagram of the experiment apparatus. If diagram is properly labeled, the list of materials should be eliminated (it would be incorporated in the diagram). If the lab is such that a diagram is inappropriate, then a list of materials should be given.

PROCEDURE AND OBSERVATIONS:

Explain briefly, yet fully, what was done, how it was done, and what was observed. An outline form can be used. Use charts, tables, graphs, diagrams, etc. as necessary (this often eliminates a great deal of unnecessary writing and permits a quick securing of data or information).

RESULTS AND CONCLUSIONS:

Explain briefly, yet completely, the final results obtained. State the proof. Use sound reasoning. State conclusions in reference to the objectives listed in the beginning. Use charts, tables, graphs, diagrams, etc. as necessary.

LABORATORY
ORIENTATION

Title: Exercise in Following Directions

Unit: Laboratory Orientation

Course: Physics

1. Take the sheet of paper provided for you by your instructor and place it on your desk so that the longest dimension is vertical.
2. Mark the lower right hand corner with a small "x".
3. Fold the corner with the "x" up and to the left making the left edges of the paper parallel.
4. Crease the paper.
5. Cut off the excess along the top of the paper.
6. Unfold the paper and check. Do you have a square?
7. Fold the paper back and place on desk so the creased edge is at the top and horizontal. The corner with the "x" should be pointing down.
8. Divide the creased edge into three equal parts. Place small marks where necessary to indicate the thirds.
9. Take the left corner and fold it to the right, making certain that the bottom edge it now makes is parallel to the creased edge. Stop at the first mark for the "thirds" and crease the paper.
10. Do the same for the right side, except for the fact that the fold is made to the left.
11. Slightly open (separate) the top overlapping paper (the one you just folded over). Grasp the top section of the corner at the bottom and fold it into this opening until it can go no farther and make a crease.
12. Fold the remaining section of the corner at the bottom back and make a crease.
13. Grasp what you have made in one hand by the widest part with the original creased edge down. You should be holding the wide part from left to right.
14. Squeeze gently. Did it open up? What did you make?

Title: Exercise in Following Directions

INSTRUCTOR'S NOTES

The activity is intended to be a fun activity and is an adaptation of "Origami" (the Japanese art of paper folding). Its purpose is to get students to learn the importance of following directions.

The resulting item, fashioned by the students, should be a paper drinking cup. Have them try out their product for this purpose.

For this activity the student will need a piece of paper (8½ x 11 will be more than large enough), a pair of scissors, and a pencil.

COMMENTS:

Title: Laboratory Safety Rules and Regulations

Unit: Laboratory Orientation

Course: Physics

1. Absolutely no horseplay in the lab.
2. All instructions for the lab are to be followed carefully and exactly as indicated. If you have any questions, ask your instructor.
3. Perform no unauthorized experiments.
4. Working in the lab is not allowed. All lab work is to be done during the regular lab period or during the supervised make-up time.
5. If you are cut, burned, or injured in the lab in any way, notify the instructor at once so appropriate action may be taken.
6. In case of fire, clear the area and notify the instructor at once. Note where the fire extinguisher is located. Remember that wet towels are also efficient for smothering flames.
7. If a person's clothing catches fire, make the person lie down, then smother the flames with a blanket. Be especially careful of loose clothing, clothing of synthetic materials, and hair when working with open flames. Always wear a lab apron to protect your clothing and confine hair when in the lab.
8. Wear approved eye protection when in the lab. If you get anything in your eye, wash it with flowing water for 15 to 20 minutes. Report the incident to your instructor.
9. Do not force glass tubing into stoppers. Use a towel to protect your hands.
10. Clean up all broken glass immediately. Do not use your hands; use a brush or towel. Dispose of glass in the special container designated by your instructor. Do not use the regular trash can.
11. When heating a substance, always point it away from everyone. Allow burners and other apparatus to cool before handling them.
12. Do not turn on power supplies or energize any circuits until instructed to do so. Treat electricity with respect--Do not make yourself a part of the circuit.

I have read these rules and will observe them for this course.

Signature _____

Title: Laboratory Safety Rules and Regulations

INSTRUCTOR'S NOTES

The instructor may use these safety rules and regulations as a guide. More specific rules should be added as they apply to different situations. They should include the specific policies of the instructor.

Specific locations, for example, of the fire extinguisher, eye wash fountain, emergency shutoffs, emergency exits, etc. should be listed on the sheet.

The rules and regulations should be thoroughly reviewed and discussed. The students should then sign the sheet and it should be kept on file.

The rules should be enforced at all times.

A lab safety test may also be prepared and administered. It should also be kept on file. A pre-determined passing score should be achieved by the student before being allowed to work in the lab.

The instructor should contact the school nurse to determine accepted procedures in the event of accident or injury.

COMMENTS:

MECHANICS

Title: LAB--Vernier and Micrometer Devices

Unit: Mechanics

Course: Physics

Purpose:

To study the principles of vernier scales and the micrometer caliper for very accurate measurement.

Materials Required:

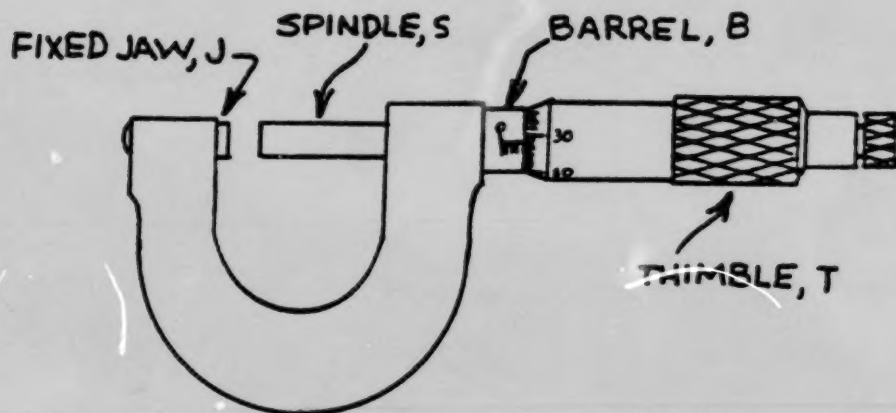
Vernier caliper and micrometer calipers (both with metric and English scales), bolts and nuts, piece of wire, various other tools and materials.

Information:

THE VERNIER CALIPER-- With a decimal vernier it is possible to measure accurately down to one tenth of the smallest division on the fixed scale. The vernier is a sliding scale that moves over the fixed scale. Ten divisions on the vernier equal nine divisions on the fixed scale.

If the zero mark on the vernier coincides with any division on the fixed scale, the reading is exactly that of that division on the fixed scale and we ignore the vernier. But if division No. 1 of the vernier coincides with some division of the fixed scale, the reading is one tenth more than the fixed scale division nearest the vernier zero. If division No. 3 of the vernier coincides with some division of the fixed scale, the reading is three tenths more than the fixed scale division to the left of vernier zero.

THE MICROMETER CALIPER-- The micrometer caliper is used to measure the diameter of small rods and wires and the thickness of sheet material such as metals and paper. It consists of a barrel, B, carrying a scale: a movable spindle, S; a thimble, T; and a fixed jaw, J.



PAGE TWO

The scale is in two parts. One part runs lengthwise of the barrel. This is marked off into millimeter divisions. The rotating thimble, moving back and forth on a screw thread, is marked around the edge into fifty divisions. Two complete turns of the thimble move it one space (1 mm) along the fixed scale.

The object being measured is placed between J and S. The thimble is turned, advancing the spindle, S, until the object is firmly in contact both with J and S. Take the reading on the fixed scale. Add to it the reading on the thimble. If the reading on the fixed scale is 0.4 cm, and the reading on the thimble is 65 (1 turn + 15 spaces) the final reading is the sum of these, or 0.465 cm.

Procedure:

(FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

PART 1.....THE VERNIER CALIPER

1. If you have the combined inside and outside calipers, measure the diameter of the hole in the nut, then measure the diameter of the bolt.
2. Compare your measurements using both the metric and English systems each time you make your measurements.
3. Measure ten different objects or tools and copy down your results.

PART 2.....THE MICROMETER CALIPER

1. For practice use the micrometer to measure the diameter of a piece of wire, a hair, or the thickness of a sheet of paper.
2. Compare your measurements using both the metric and English systems each time you make your measurement.
3. Measure ten different objects or tools and copy down your results.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Measurement of Volume

Unit: Mechanics

Course: Physics

Purpose:

To find the volume of a solid.

Materials Required:

Vernier caliper, ruler or meter stick, regular blocks of wood, ball bearings of various size, and a metal cylinder.

Information:

In this experiment you can make use of the experience gained in the LAB--Vernier and Micrometer Devices. By simple math, units of length may be used in finding the volume of regular solids.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

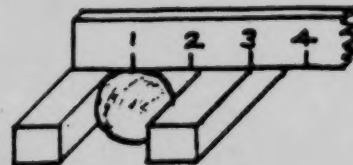
- A. Measure the length, width, thickness, of one of the blocks of wood with the ruler; with the caliper. Record the readings in the table. Average readings of two trials. Calculate its volume.

BLOCK	TRIAL	LENGTH	WIDTH	THICKNESS	VOLUME
WITH RULER	1				X
	2				X
	AV.				
WITH CALIPER	1				X
	2				X
	AV.				

- B. Measure the diameter of the ball bearing between two blocks and measure the distance between the blocks with a ruler.

Measure the diameter with the calipers. Record in the table. Calculate the volume by using this formula:

$$V = \frac{3.14 \times \text{DIA}^3}{6}$$



Title: LAB--Measurement of Volume

PAGE TWO

BEARING	TRIAL	DIAMETER	VOLUME
WITH RULER	1		X
	2		X
	AV.		
WITH CALIPER	1		X
	2		X
	AV.		

- C. Measure the diameter and length of the metal cylinder with the ruler, and with the caliper, Record in table. Calculate volume by this formula: $V = 3.14 \times \text{radius}^2 \times \text{length}$.

CYLINDER	TRIAL	DIAMETER	LENGTH	VOLUME
WITH RULER	1			X
	2			X
	AV.			
WITH CALIPER	1			X
	2			X
	AV.			

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Surface Tension

Unit: Mechanics

Course: Physics

Purpose:

To show that the surface of liquids has a force of tension, or the desire to want to shrink to the smallest possible size.

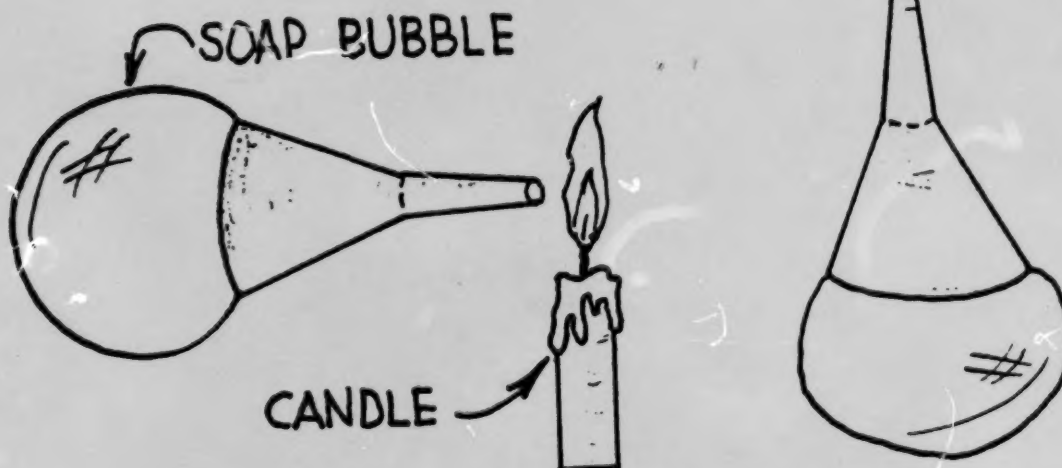
Materials Required:

Funnel, soap, pan with water.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Put soap in water to make good suds and bubbles.
2. Light a candle.
3. Put wide end of funnel in suds and blow a large bubble.
4. Keep large bubble by putting thumb on small end of the funnel.
5. Bring small end to flame and remove thumb.



6. Make another bubble.
7. Hold the small end up. (Note what happens to the bubble).

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Surface Tension

PAGE TWO

Questions:

1. Explain why there was a pressure built up inside the bubble.
2. In the second bubble why doesn't gravity pull the bubble down and hold it there?
3. What force prevents water from seeking its own level?

Title: LAB--Hooke's Law

Unit: Mechanics

Course: Physics

Purpose:

To prove Hooke's Law and to compare the results of springs of different material using Hooke's Law.

Materials Required:

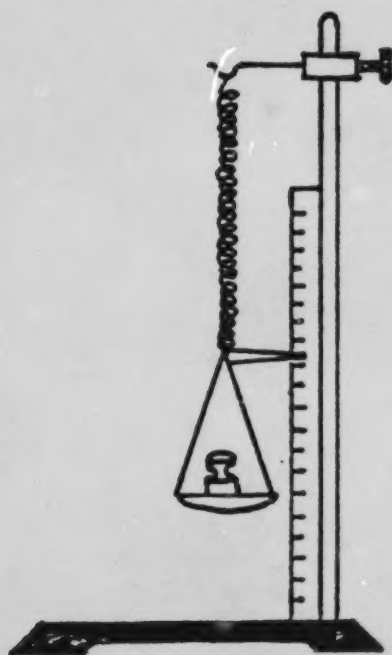
Hooke's Law apparatus or assemble a similar apparatus, Helical springs, (springs should be of different material 4-5" long and 1/2" in diameter, preferably aluminum, brass, copper, iron, steel); a pointer, a ring stand, supporting rod, a set of weights, and a meter stick.

Information:

Hooke's Law states: The distance an object is stretched is proportional to the force exerted on the object. ($F = kL$). The size of the stretch (L) is proportional to the weight (F) where (k) is a constant number. Knowing the value of the constant k , you can find the stretch on a spring until the elastic limit is exceeded.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.



1. Fasten one end of a spring to a support and clamp the meter stick securely besides it so that the pointer will indicate the displacement of the spring.
2. Record as the zero reading the position of the pointer with no mass in the scale pan.
3. Place a 1-g mass in the pan, and again note the position of the pointer. Make 10 trials increasing the load each time.
4. To obtain the total stretch, subtract the zero reading from each reading of the position of the pointer. Compute the stretch per unit weight by dividing the total stretch by the load.
5. Plot a graph to show the relation between load and the total stretch.
6. Repeat the above procedure this time using springs of different material.

CLEAN UP YOUR WORK STATION, BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.
INSTRUCTOR'S INITIALS _____

Title: LAB--Hooke's Law

INSTRUCTOR'S NOTES

Before you begin this experiment it would be wise to stop into your machine shop and have them make springs of different material for you.

Title: LAB--The Pulley

Unit: Mechanics

Course: Physics

Purpose:

To determine the Mechanical Advantage of a pulley system, the relationship between the Mechanical Advantage and the number of ropes supporting the load, and the relationship between Mechanical Advantage and the distance moved by effort and resistance.

Materials Required:

String, rulers, spring balances, support rod, a set of weights, two single pulley blocks, and a two double pulley block.

Information:

A pulley system explains some principles that govern the operation of all machines. The force applied to a machine is called the Effort, (E). The load which the Effort overcomes is called the Resistance (R). Mechanical Advantage (M.A.) can be found by dividing the Effort into the Resistance
$$M.A. = \frac{R}{E}$$

Mechanical Advantage is the number of times the Effort force is multiplied by a machine.

D_r = Distance the resistance force moves.

D_e = Distance the effort force moves.

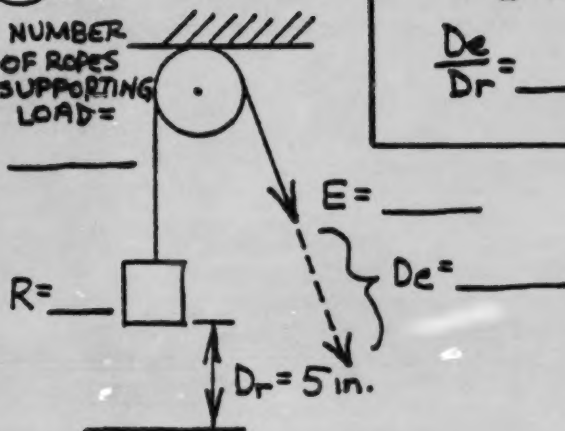
Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Set up each of the pulley systems shown in the drawings on the following page. Determine all unknowns R = Resistance which you select from the set of weights. Study each diagram before performing the experiment.

(A)

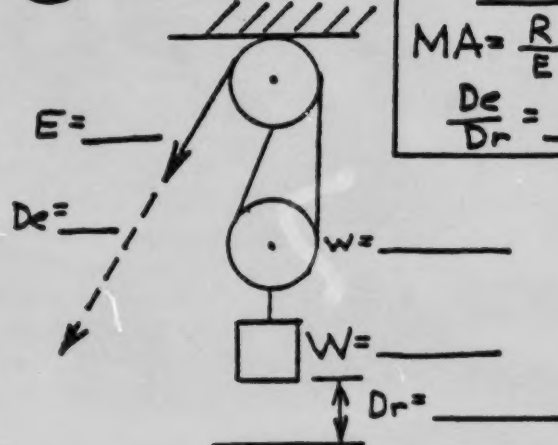
NUMBER
OF ROPES
SUPPORTING
LOAD=



$$MA = \frac{R}{E} =$$

$$\frac{De}{Dr} =$$

(B)

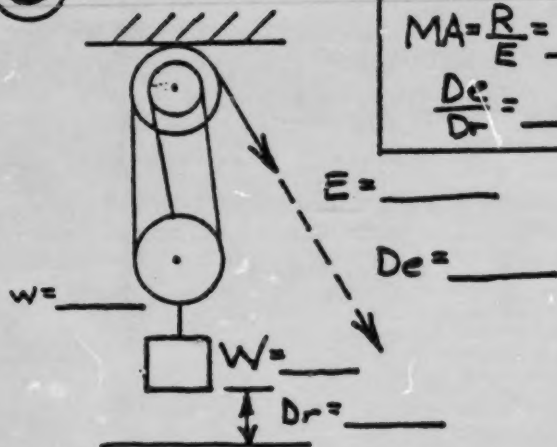


$$R = W + w =$$

$$MA = \frac{R}{E} =$$

$$\frac{De}{Dr} =$$

(C)

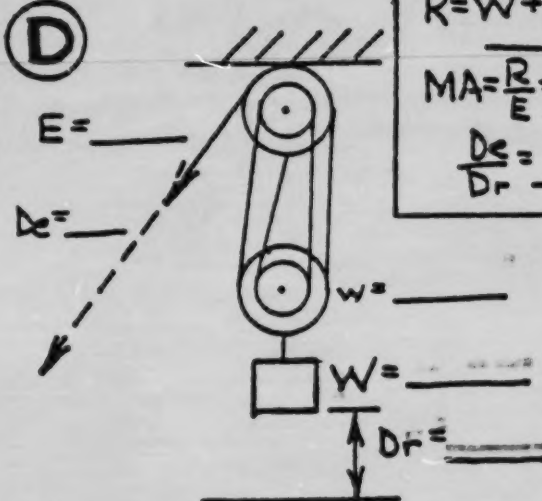


$$R = W + w =$$

$$MA = \frac{R}{E} =$$

$$\frac{De}{Dr} =$$

(D)



$$R = W + w =$$

$$MA = \frac{R}{E} =$$

$$\frac{De}{Dr} =$$

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--The Mechanical Advantage of a Bolt

Unit: Mechanics

Course: Physics

Purpose:

The Mechanical Advantage of various bolts will be determined mathematically. The student will also be able to see the comparison between the inclined plane and the threads on a bolt.

Materials Required:

5 volts of various sizes, a large bolt and nut (1"), 8" adjustable wrench, and small vise.

Information:

The bolt is one of the most useful machines we have. Its important use is to fasten parts of a mechanism together.

In this experiment we will be using two formulas:

$$\begin{aligned} \text{M.A.} &= \frac{\text{Effort distance (De)}}{\text{Resistance distance (Dr)}} \\ &= \frac{\text{Circumference of wrench circle } (2 \times \pi \times r)}{\text{Pitch of bolt (p)}} \end{aligned}$$

$$\text{M.A.} = \frac{De}{Dr} = \frac{2 \times \pi \times r}{p}$$

*The distance between threads is called the pitch.

Example if a bolt has 16 threads to the inch the pitch of the bolt - the distance between threads - is 1/16 of an inch.

Note the other formula is in the procedure below.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

PART I. A. Students will find the M.A. of a bolt by counting the number of threads per inch. Compute from this the distance between the threads (the Pitch).

B. As a check measure the pitch directly with calipers.

C. Measure the diameter of the bolt.

Title: LAB--The Mechanical Advantage of a Bolt

PAGE TWO

- D. Calculate the M.A. The Mechanical advantage is the ratio of π x the diameter of the bolt (effort distance) to the pitch (resistance distance).
- E. Repeat the above procedure using the other bolts.

PART II. A. Determine the pitch of the large bolt with nut.

- B. Place nut and bolt in vise.
- C. Place wrench on bolt.
- D. Now determine the M.A. according to the formula in the Information section of this lab.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--The Wheel and Axle 1

Unit: Mechanics

Course: Physics

Purpose:

To show that if a large force is applied to the larger wheel then a small force will be applied to a smaller wheel.

Materials Required:

A piece of wood 1" x 4" x 8"; 3 pairs of wheels of different diameters, same axle size, made from plywood if necessary;
4 - 2" x 1/4" bolts (4 nuts and 4 washers); Dowel to fit inside spring loosely; Curtain rod spring; 4 small staples.

Information:

In this experiment you can solve for velocity, by measuring the distance and the time the car travels,

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

You can also solve for acceleration, by rearranging the following formula:

$$\text{Distance (S)} = \frac{\text{acceleration} \times \text{time}^2}{2}$$

$$\text{or } S = \frac{a \times t^2}{2}$$

And you can also solve for force.

$$\text{Force (F)} = \frac{\text{Mass} \times \text{Velocity}^2}{\text{Radius}}$$

$$\text{or } F = \frac{M \times V^2}{r}$$

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Cut Board (See Sketch for dimensions).
2. Drill holes in board for front axle, 1/4" and rear axle (loosely) and line up.
3. Drill holes in dowel for bolts, tight fit.
4. Cut heads off two bolts.
5. Attach front wheels as shown.
6. Press beheaded bolts in dowel, thread end out, through the board and washer

Title: LAB--The Pulley

INSTRUCTOR'S NOTES

Before proceeding with the experiment, it would be a good idea for the instructor to demonstrate each diagram and explain how the data applies to each calculation.

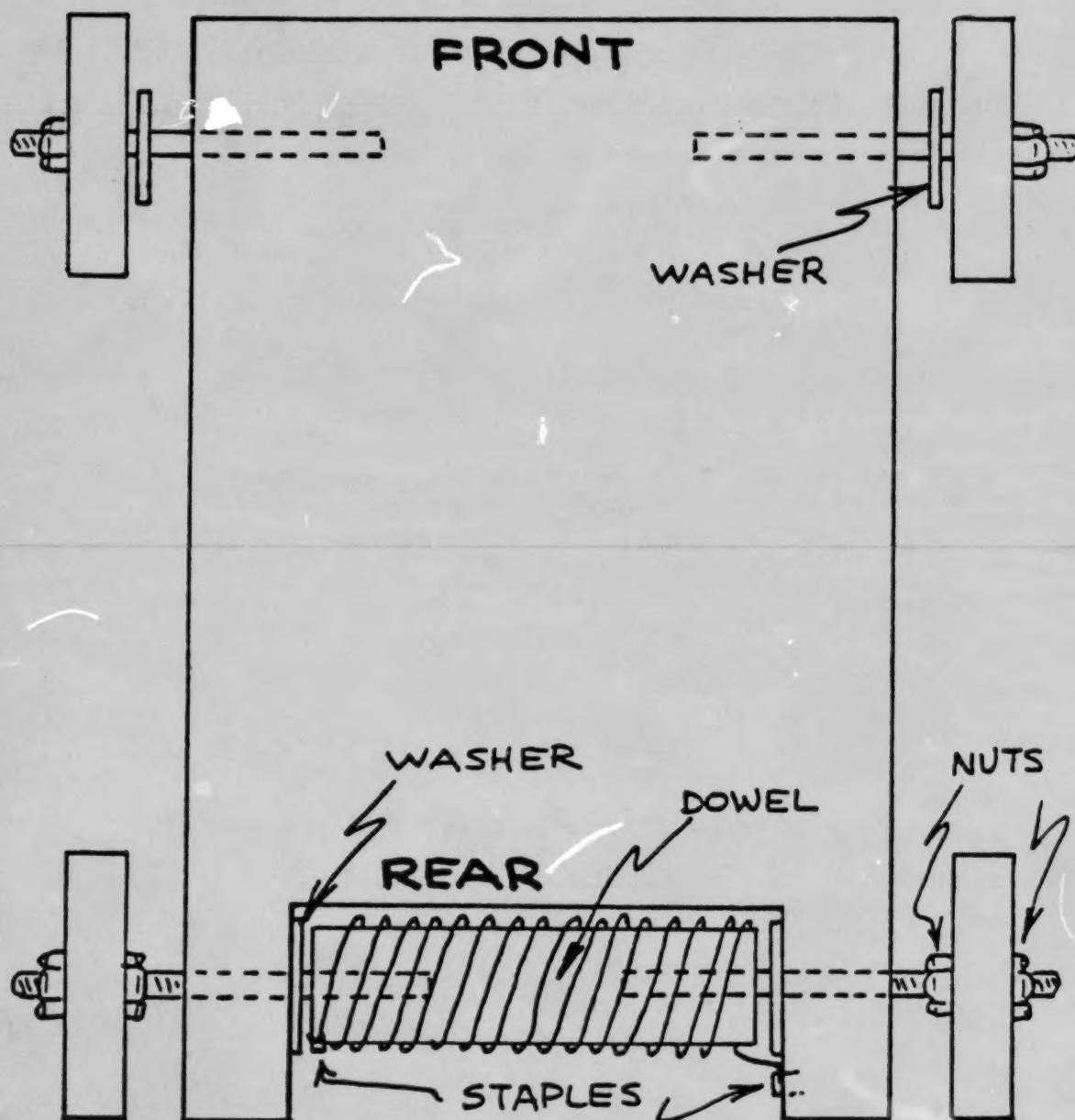
COMMENTS:

Title: LAB--The Wheel and Axle 1

PAGE TWO

7. Staple one end of spring to end of dowel. Attach rear wheels with nuts.
8. Staple other end of spring to board as shown.
9. Turn rear wheel backward a certain number of times (not too tight)
10. Stop watch the time it takes to go a certain distance, measure this distance.
11. Replace rear wheels with a different diameter size.
12. Wind the wheels the same number of turns.
13. Stop watch the time it takes to go the same distance.
14. Do the same with the third set of wheels.
15. Make sure to measure the radius of the three sets of wheels you are using, this will help you solve the Force formula.
16. Be sure to note what set of wheels made the fastest time.
17. Explain why acceleration would be slower if weights were on the car.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____



Title: LAB--The Wheel and Axle 2

Unit: Mechanics

Course: Physics

Purpose:

To determine the Mechanical Advantage of the Crank and Axle.

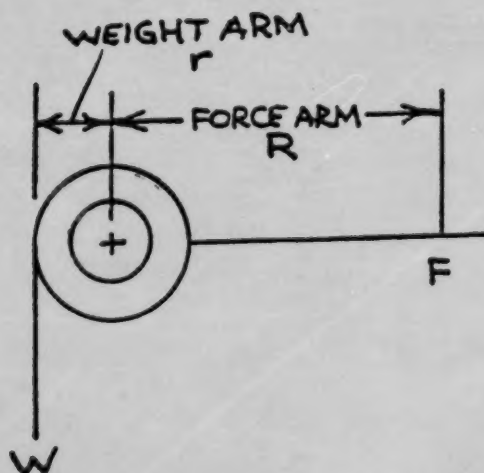
Materials Required:

Crank and Axle, Rope, weights and hanger, spring balance, meter stick.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

- A. Attach 10 lb. weight to axle with a rope leaving weight on the floor.
- B. Adjust crank to radius length of 18 inches and measure diameter of the axle.
- C. Turn crank to take up slack in the rope then measure, pull on the crank required to lift the weight, with the spring balance. Record in data table.
- D. Again, without spring balance, take up slack in rope and give crank one complete turn. Measure the distance the weight is lifted. Record.
- E. Repeat using crank distance of 12" and 6".
- F. Repeat above using weight of 30 lbs.



Title: LAB--The Wheel and Axle 2

PAGE TWO

AXLE RADIUS	WEIGHT(W)	CRANK RADIUS	FORCE (F)	W x W ARM	F x F ARM	MA = $\frac{W}{F}$
	10	18				
	10	12				
	10	6				
	30	18				
	30	12				
	30	6				
CRANK LENGTH	DISTANCE W MOVES AT 1 TURN OF CRANK	DISTANCE F MOVES AT 1 TURN OF CRANK (2 π R)	INPUT F DIST. x F	OUTPUT W DIST. x W	MA = $\frac{F \text{ DIST.}}{W \text{ DIST.}}$	
18						
12						
6						

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Three Types of Levers

Unit: Mechanics

Course: Physics

Purpose:

To compare the Mechanical Advantage of the three types of levers.

Materials Required:

Carpenter's horse, Two by four about 6½ feet long (lever), weights - one about 50 lbs of material and another 25-30 lbs. of material; large spring balance, (100 lbs. capacity),

Information:

In each of the three different levers below, you can measure the effort E that is required to raise a resistance R . You can calculate the ratio R/E the Mechanical Advantage (M.A.) of each lever. The distance from the fulcrum to the effort E or resistance R is called an arm. One is the effort arm, A_e , the other is the resistance arm, A_r . You can compare the M.A. with the ratio of the effort arm A_e to the resistance arm A_r . When you describe the position of the resistance or effort, make all the measurements from the fulcrum.

Procedure;

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

- A. Place lever so that it rests on the horse at the central point of the lever. Hang 50 lb. weight on one end. Attach spring balance to other end of the lever and pull down with sufficient force to raise the weight from the floor (Figure 1). In your data table record 1. Reading of spring balance, 2. Weight, 3. Distance weight moved, 4. Distance force moved, 5. Length of weight arm of lever, 6. Length of force arm, 7. Mechanical Advantage.

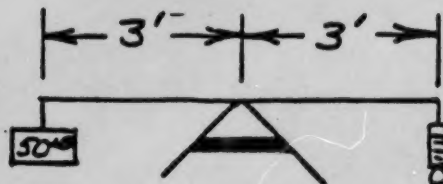


FIG: 1

- B. Place the lever so that the fulcrum is two feet from the end on which the weight is supported, and repeat as in Step 1. Repeat experiment, changing length of weight arm and force arm. Compare mechanical advantage with ratio of force arm to weight arm.
- C. Place lever so that one end rests on the horse. Hang 50 lb. weight in middle of lever and with scale attached to free end lift until weight clears the floor. (Figure 2). Record all data.

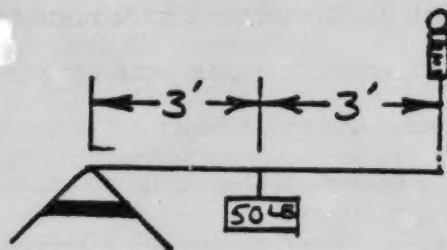


FIG. 2

- D. Place lever so that one end is resting on horse (Fasten the lever so that it can not move upward.) Hang the weight on the other end of the lever, and attach the spring balance to the middle. Lift with scale until weight clears the floor (Figure 3). Record in table. (For this step use a 25 to 30 lb. weight.) Repeat the operation in this step attaching spring balance to points both nearer the weight and nearer the fulcrum.

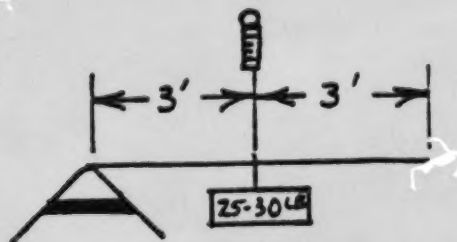


FIG. 3

Title: LAB--Three Types of Levers

PAGE THREE

TRIAL	SCALE READING	DISTANCE WEIGHT MOVED	DISTANCE FORCE MOVED	WEIGHT	LENGTH OF WEIGHT ARM	LENGTH OF FORCE ARM	MECHANICAL ADVANTAGE
1							
2							
3							
4							
5							
6							
7							

Title: LAB--Sliding Friction

Unit: Mechanics

Course: Physics

Purpose:

To determine the differences in sliding friction due to the kind of materials used, the load on the contact surface and lubrication.

Materials Required:

Microscope, Iron plates (1 rough, 1 smooth), Blocks (rectangular)
1 - rough cast iron, 1 - smooth cast iron, 1 - smooth brass,
1 - smooth aluminum (each block should weigh 3 lbs.), Spring balance,
can of oil.

Information:

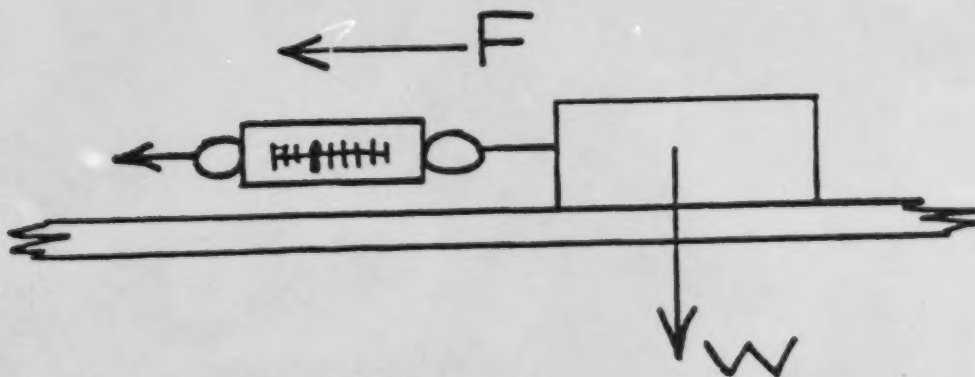
Force needed to overcome $\frac{\text{friction (F)}}{\text{weight (W)}} = \text{a constant (k)}$

$$\text{or } \frac{F}{W} = k$$

This formula says that the force of friction is a constant fraction of the object's weight. The constant fraction, is called the coefficient of friction. Note that the more slippery the surface, the smaller the coefficient of friction.

Coefficients of Friction

Wood on wood, dry	0.25 to 0.50
Wood on wood, soapy	0.20
Metal on metal, dry	0.15 to 0.20
Metal on metal, greased	0.03 to 0.05
Metal on metal, rolling about	0.002
Rubber on concrete, dry	0.06 to 0.07



Title: LAB--Sliding Friction

PAGE TWO

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Examine the surface of the materials used under a microscope.
2. Attach a spring balance to a smooth rectangular block and draw the block on a smooth plate, using the largest surface of the block. Read the balance while the block is moving slowly over the plate. Repeat using first the side then the end of the block. Record readings in the data table.
3. Repeat using a rough block and rough plate.
4. Try the experiment with blocks of various sizes and materials.
5. Put oil on the plate and repeat Parts 2 and 3.
6. Solve for the coefficient of friction using the formula given in the Information Section.

MATERIALS		APPEARANCE OF SURFACE UNDER MICROSCOPE		SPRING BALANCE READING					
				DRY			LUBRICATED		
BLOCK	PLATE	BLOCK	PLATE	BOT.	SIDE	END	BOT.	SIDE	END
C.I.	C.I.	SMOOTH	SMOOTH						
C.I.	C.I.	ROUGH	ROUGH						
C.I.	C.I.	ROUGH	SMOOTH						
BRASS	C.I.	SMOOTH	SMOOTH						
ALUM.	C.I.	SMOOTH	SMOOTH						

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACE AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--The Coefficient of Sliding Friction

Unit: Mechanics

Course: Physics

Purpose:

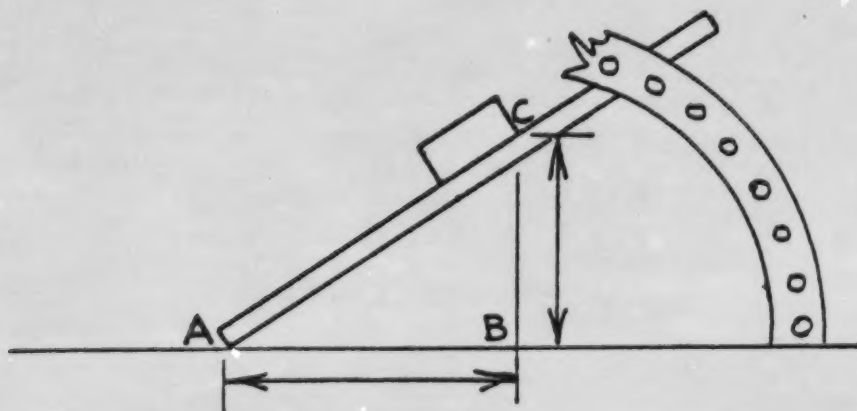
To determine the coefficient of sliding friction by using an inclined plane.

Materials Required:

A rectangular block; wood, cast iron, brick, aluminum of convenient size, inclined plane, adjustable to various angles; sheets of sand-paper, sheet iron, and glass (to place on the incline plane).

Information:

The coefficient of friction is the tangent of the angle (vertical distance over horizontal distance) of the incline on which the material will just slide.



Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Place the cast iron blocks on the wood surface of the inclined plane.

Vary the angle of the incline until the block, after being started, will just slide slowly down the incline.

Measure off any convenient distance from point A such as point B, (10 inches) (See Sketch). Measure perpendicular distance from B to C.

Title: LAB--The Coefficient of Sliding Friction

PAGE TWO

Calculate the coefficient of friction from formula

$$C.F. = \frac{\text{Vertical Distance}}{\text{Horizontal Distance}}$$

Repeat the experiment with various blocks and materials on the surface of the incline plane. Record readings in the data table.

MATERIALS		HORIZONTAL DISTANCE (AB)	VERTICAL DISTANCE (BC)	COEFFICIENT OF FRICTION
BLOCK	INCLINED SURFACE			
CAST IRON	WOOD			
CAST IRON	SHEET IRON			
CAST IRON	SANDPAPER			
WOOD	WOOD			
WOOD	SHEET IRON			
WOOD	GLASS			
BRASS	WOOD			
BRASS	SHEET IRON			
BRASS	SANDPAPER			
BRASS	GLASS			

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS
DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Forces Acting on an Automobile in Motion and at Rest

Unit: Mechanics

Course: Physics

Purpose:

To show forces at work on a resting and moving automobile.

Materials Required:

Toy auto, pulley, a set of weights, string, electric fan

Procedure:

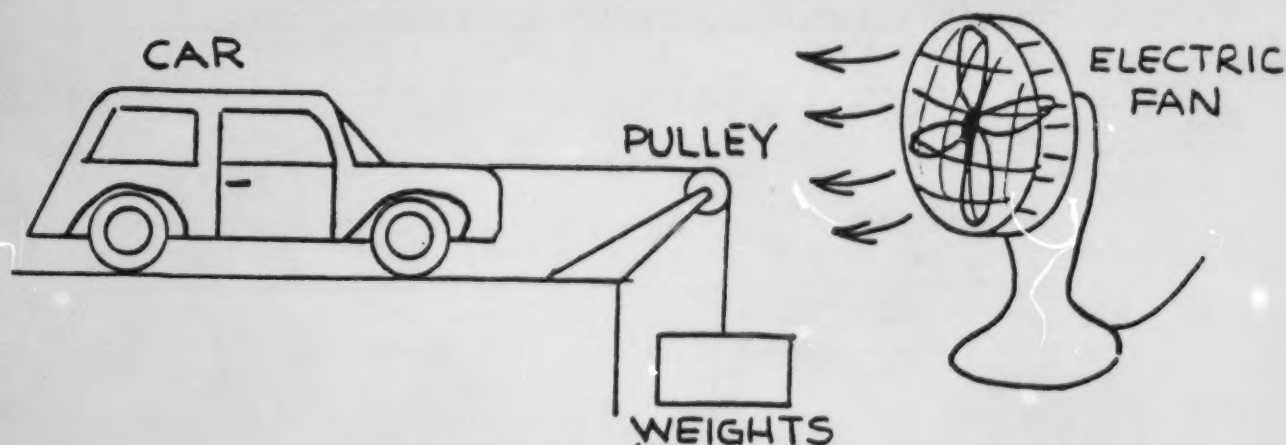
FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Arrange the experiment as shown.

Apply weights until the car moves.

Take off some of the weights after the car starts but keep it moving.

Do the same with fan in different positions.



CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Questions:

1. What weights were required to start the car?
2. What weights were required to keep the car in motion?
3. What effect does the fan have upon the car?

Title: LAB--Vectors

Unit: Mechanics

Course: Physics

Purpose:

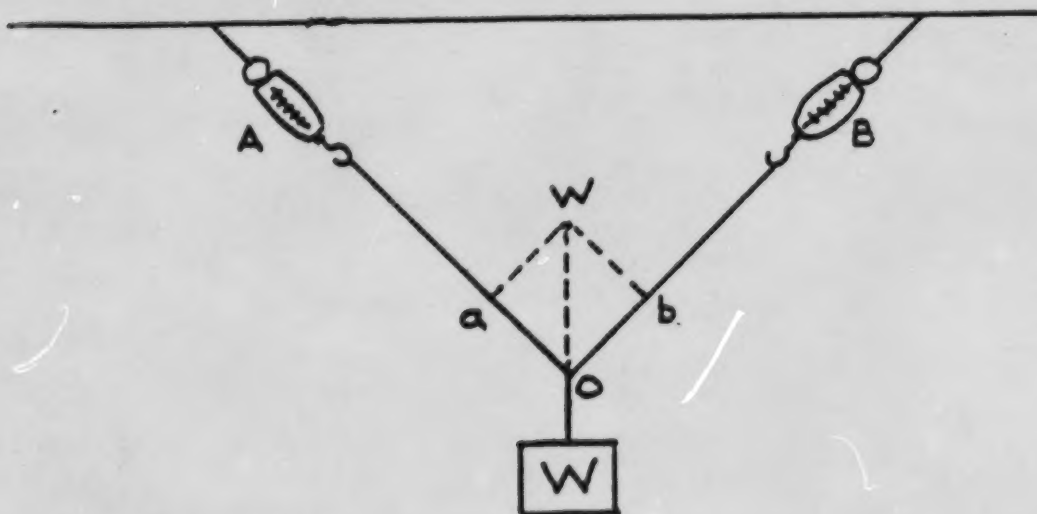
To determine the magnitude and the direction of the resultant of two component angular forces, to be verified graphically.

Materials Required:

Two spring balances; a set of weights; 12" scale and/or a meter stick; drawing board; rope or string.

Information:

Before beginning this experiment it would be wise to review the Pythagorean theorem, and the sine and cosine functions.



Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

- A. Support the balances A and B from hooks in the molding at the top of a blackboard or from the cross support of an experimental table.

Title: LAB--Vectors

PAGE TWO

- B. Support weight as shown adjusting length of cords until one spring balance registers approximately 20 lbs. and the other approximately 15 lbs.
- C. Place behind the cords a drawing board to which a paper is attached. Sketch on paper line of weight OW, lines OA and OB, or sketch directly on blackboard.
- D. Note on paper, readings of scales A and B as well as weight W.
- E. Choose a scale which is convenient to plot and which makes the diagram of proper size for the size of paper. For example 5 lbs. to the inch. Draw parallelogram to this scale. Now draw diagonal, and scale the length. Label all intersections and readings.
- F. Repeat the above experiment, this time varying (W).

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Equilibrium

Unit: Mechanics

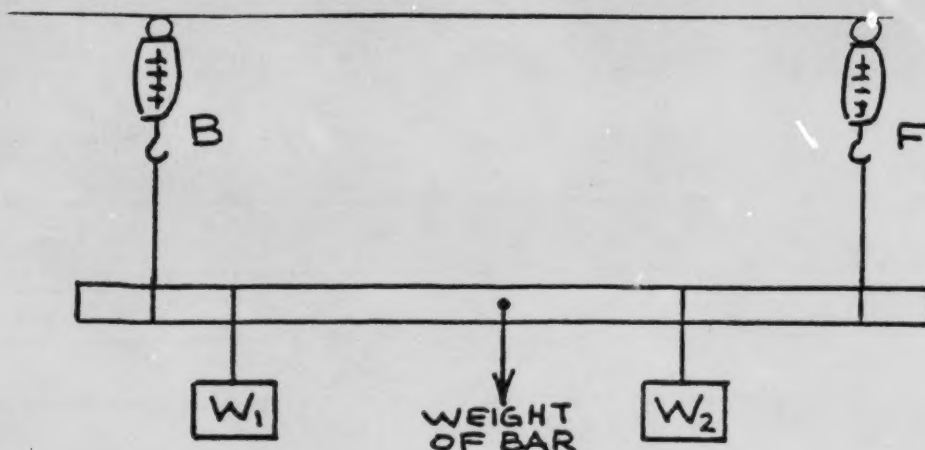
Course: Physics

Purpose:

To show that when an object is in a condition of equilibrium the sum of the clockwise moments equal the sum of the counterclockwise moments.

Materials Required:

2 Spring balances; a set of weights; metal bar; standard weight hangers; meter stick.



Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Suspend two spring balances from a suitable support or supports 30" apart.
2. Weigh the bar and each weight and weight hanger separately and record the reading in the data table.
3. Place the bar in the hooks of the spring balances as shown in the sketch and adjust until the spring balances are vertical.
4. Place W_1 on bar at a distance of 5" to right of B. Place W_2 on the bar at a distance of 8" to the left of F.
5. Read spring balance and record the readings in the data table.

6. Construct a force diagram.
7. Determine moments of the force about B and then about F in inch lbs. and record in the data table.

FORCES IN LB.			MOMENTS AROUND B IN INCH LBS.		MOMENTS AROUND F IN INCH LBS.	
AT	UP	DOWN	CLOCKWISE	COUNTER- CLOCKWISE	CLOCKWISE	COUNTER- CLOCKWISE
TOTALS						

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACE AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Resolution of Forces

Unit: Mechanics

Course: Physics

Purpose:

To determine the magnitudes of the components with the magnitude and the direction of the resultant known and with the angles of the components known.

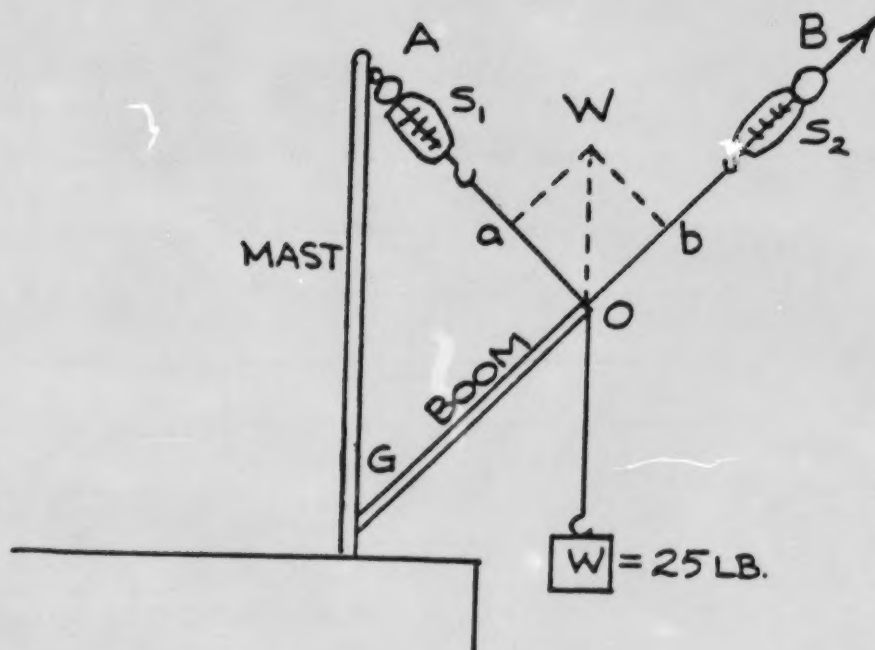
Materials Required:

Two spring balances; a set of weights; 12" scale or meter stick; protractor; crane apparatus .. boom and mast; string or rope.

Information:

Before beginning this experiment it would be wise to review the Pythagorean theorem, and the sine and cosine functions.

By means of the Parallelogram method, it is possible to compute the forces, exerted by W on the supporting parts of the crane.



Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Title: LAB--Resolution of Forces

PAGE TWO

- A. Arrange the apparatus as shown in the sketch.
- B. Record W. Measure GO, GA, and QA, accurately.
- C. Draw a force diagram to scale. Extend Ow to a scale $\frac{1}{4} = 5$ lbs. Complete parallelogram Oawb.
- D. Determine the amount of force Oz and Ob in force diagram.
- E. Read spring balance S_1 to obtain tension in the cord QA.
- F. Read the spring balance S_2 to obtain compression in OG.
- G. Compare readings of S_1 and S_2 with the results of force diagram.
- H. In the second trial, fasten balance S_1 to another position so that the boom is raised to another position. Do not vary the weight (w). Record your data in the space provided.
- I. In the third trial keep the same angle but vary (w), and record your data.

TRIAL	1	2	3
WEIGHT (W)			
COMPUTED TENSION (Oa)			
COMPUTED COMPRESSION (Ob)			
MEASURED FORCE (S_1)			
MEASURED FORCE (S_2)			

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--The Rocket

Unit: Mechanics

Course: Physics

Purpose:

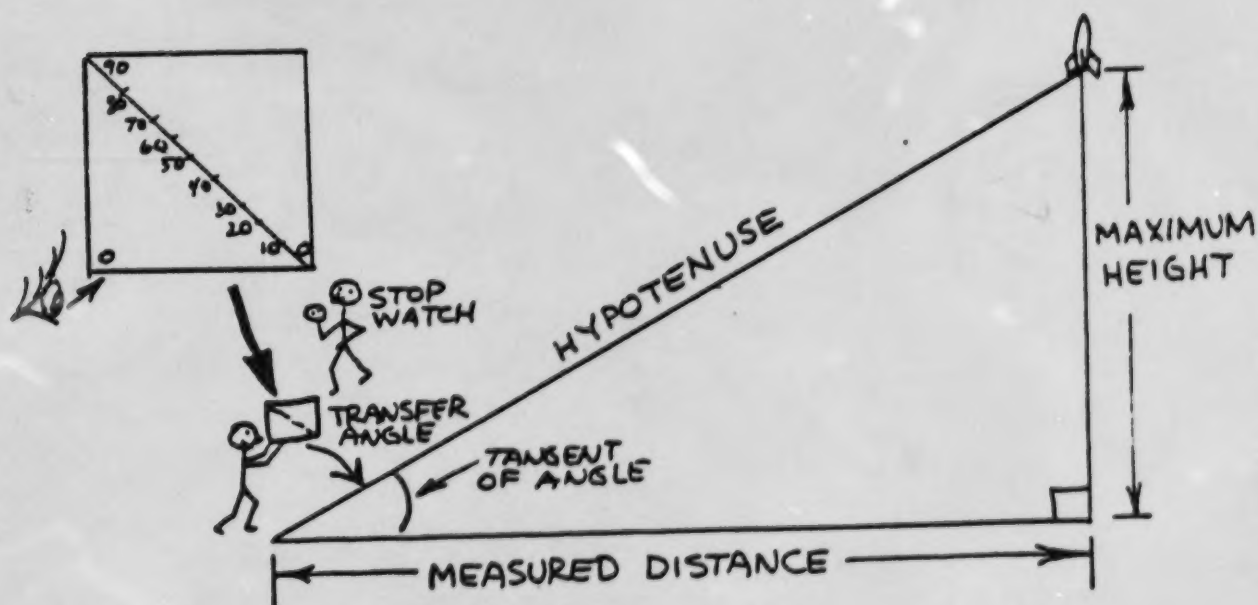
To demonstrate Newton's third law, also to calculate the velocity, the acceleration, and the height of a rocket.

Materials Required:

5 model rockets; 10 rocket engines A, B, and C; several stop watches; Tripod; 6-volt battery; Protractor scale mounted on a square piece of wood.

Information:

The height of a rocket can be determined by using simple trig. (See Figure).



The velocity can be calculated by using the formula

$$\text{Average Velocity} = \frac{\text{Distance}}{\text{Time}}$$

Title: LAB--The Rocket

PAGE TWO

Distance can be calculated by multiplying the tangent of the height of the rocket times measured distance.

Time can be taken from the stop watch, started at launch and stopped when gray smoke is not observed at the rear of the rocket.

Acceleration can be calculated from the following formula:

$$S = \frac{at^2}{2}$$

S = distance (Max. Height), Time same as that stated above

Rearrange formula and solve for, a (acceleration).

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Students can either build model rockets in school or they can be brought from home.

Set up the field as shown in the sketch. Have one of your students with a stop watch measure the time that it takes for the rocket to reach its highest point. Someone with field glasses should tell the student with the stop watch when the rocket reaches its highest point. Another student must measure the angle of the height of the rocket, this can be coordinated. When the student with field glasses states that the rocket has reached its maximum height the angle of height must be noted.

All data must be placed in the table provided, from which the required information can be calculated.

Repeat the experiment at least five times.

For best results launch on a cloudy day.

Title: LAB--The Rocket

PAGE THREE

TRIAL	MAXIMUM HEIGHT	MEASURED DISTANCE	ANGLE OF HEIGHT	SPEED/ VELOCITY	ACCELERATION
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS_____.

Title: LAB--Center of Gravity

Unit: Mechanics

Course: Physics

Purpose:

To find the center of gravity of a plane.

Materials Required:

Wooden stand or support; Pieces of cardboard (6" x 8" and 6" x 10"); pins or nails; scissors; 12" ruler or meter stick; plumb bob and string.

Information:

In this experiment not only will you calculate the center of gravity of the objects listed in the procedure; you will also test the center of gravity using the Principle of Moments.

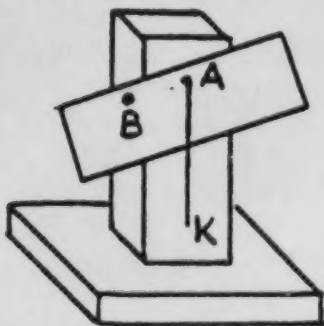


FIG. 1

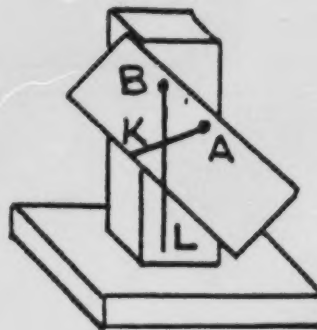


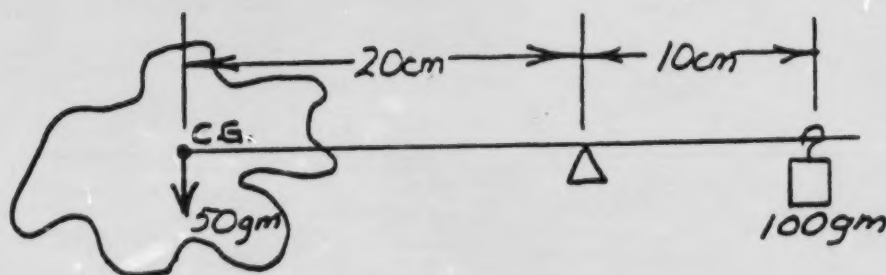
FIG. 2

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

- A. Lay out and cut a rectangle of cardboard.
- B. Hang a rectangle from a nail or pin in the support put through a hole near its edge. Suspend plumb bob from the same nail or pin, and draw a line on the rectangle corresponding to the plumb line. The arrangement is shown in Figure 1 where A is the supporting nail and AK the plumb line.

- C. Hang a rectangle from another point near its edge and draw another plumb line as before. In Figure 2, B is the second point of support and EL the second plumb line. Where lines Ak and EL intersect will be the center of gravity of the area or of the rectangle.
- D. Locate the center of the rectangle by drawing the diagonals. Note how the center of the rectangle compares with the center of gravity.
- E. Repeat the experiment using a circle, triangle, and an irregular shape object.
- F. After you have plotted the center of gravity of the objects in procedure (E), test it by the Principle of Moments. Follow the drawing below, attach the objects to a lever and then proceed to balance the objects. Then calculate the Clockwise and Counter-clockwise moments.



CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Centrifugal Force Governor

Unit: Mechanics

Course: Physics

Purpose:

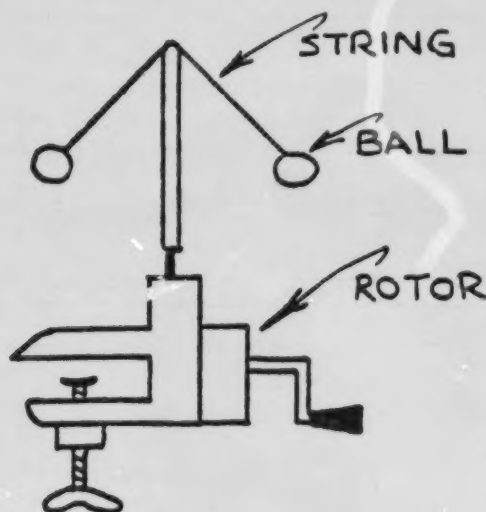
To show the operation of a simple governor.

Materials Required:

Rotor; 2 - 6" pieces of string; 2 balls with holes.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.



Attach weights to rotor as shown in sketch.

Rotate with varying speeds.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Questions:

1. What effect has the R.P.M. on the weights?
2. Where in the automobile may this be used?
3. If these weights become frozen what effect would it have on the operation of the car?

Title: LAB--Bernoulli's Principle

Unit: Mechanics

Course: Physics

Purpose:

To show that when air or water moves through a confined area it travels at a faster rate and the pressure is reduced below atmospheric pressure.

Materials Required:

Compressor or inner tube inflated; 3" rubber tubing, 3/8"; 2 - 6" glass tubes, tapered by heating; cut-off test tube; 2 rubber stoppers; 2 - 3" glass tubes; tank or jar; nail; water coloring; 2 pressure gauges.

Information:

In this experiment Bernoulli's Principle can be proven and if measurements are accurately taken it can be found mathematically. Bernoulli's principle can be written $H_t = P_s + q$. It simply states that the total pressure of a fluid is the sum of the static and dynamic pressures.

Dynamic pressure (q) cannot be measured directly as can the static pressure (P_s). However, since dynamic pressure is an indication of the kinetic energy, it can be calculated using the basic kinetic energy formula ($KE = \frac{1}{2} MV^2$), $q = \frac{1}{2} pV^2$, p = density or mass per unit volume. Bernoulli's principle can also be written: $H_t = P_s + \frac{1}{2} p V^2$. (If the density remains constant the dynamic pressure will change only when velocity changes.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

A venturi can either be purchased and then modified for this experiment, or perform the following procedure. (See drawing).

Make a small hole near one end of a rubber tube with a heated nail.

Take 12" glass rod and heat at the middle and pull apart.

Break off the tips of the tapered ends.

File the end of test tube, heat it and break it off.

Cork one end of the tube, put one hole stopper with a glass tube in the other end.

Blow at the middle of tube, using blowpipe, blowing air into the test tube.

Title: LAB--Bernoulli's Principle

PAGE TWO

Insert tapered glass tube in test tube hole and seal with wax.
Insert other tapered glass tube in small hole in rubber tube.
Assemble stoppers to test and short glass tubes.
Attach to compressor and start.

(Optional: Attach gauges where indicated for working out mathematical solution)

Notice level of liquids in glass tubes.

Squeeze where noted and observe.

Color the water.

Mathematical Solution: The mass flow past a point can be found by multiplying the mass density (ρ) which is called Rho by the cross-sectional area (A) times the velocity of flow (V).

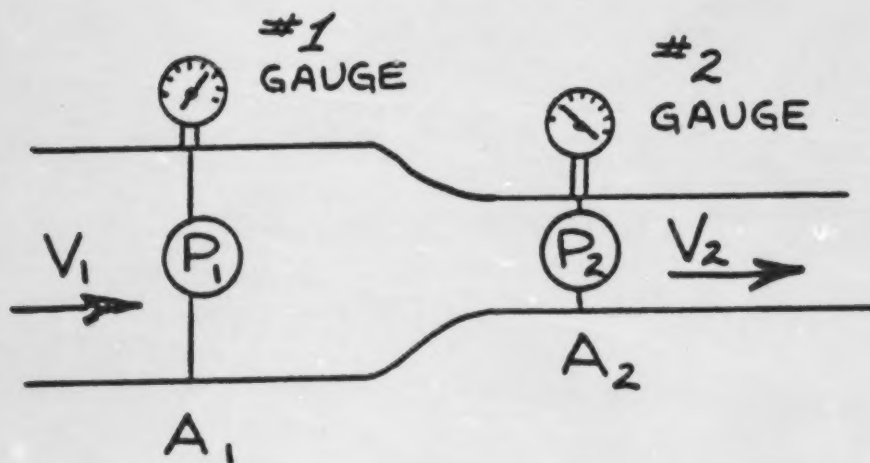
$$\text{Mass Flow} = \rho AV = \frac{\text{Mass}}{\text{sec.}}$$

Where ρ = mass per cubic foot $\left(\frac{\text{Mass}}{\text{ft}^3}\right)$

A = cross-sectional area (ft^2)

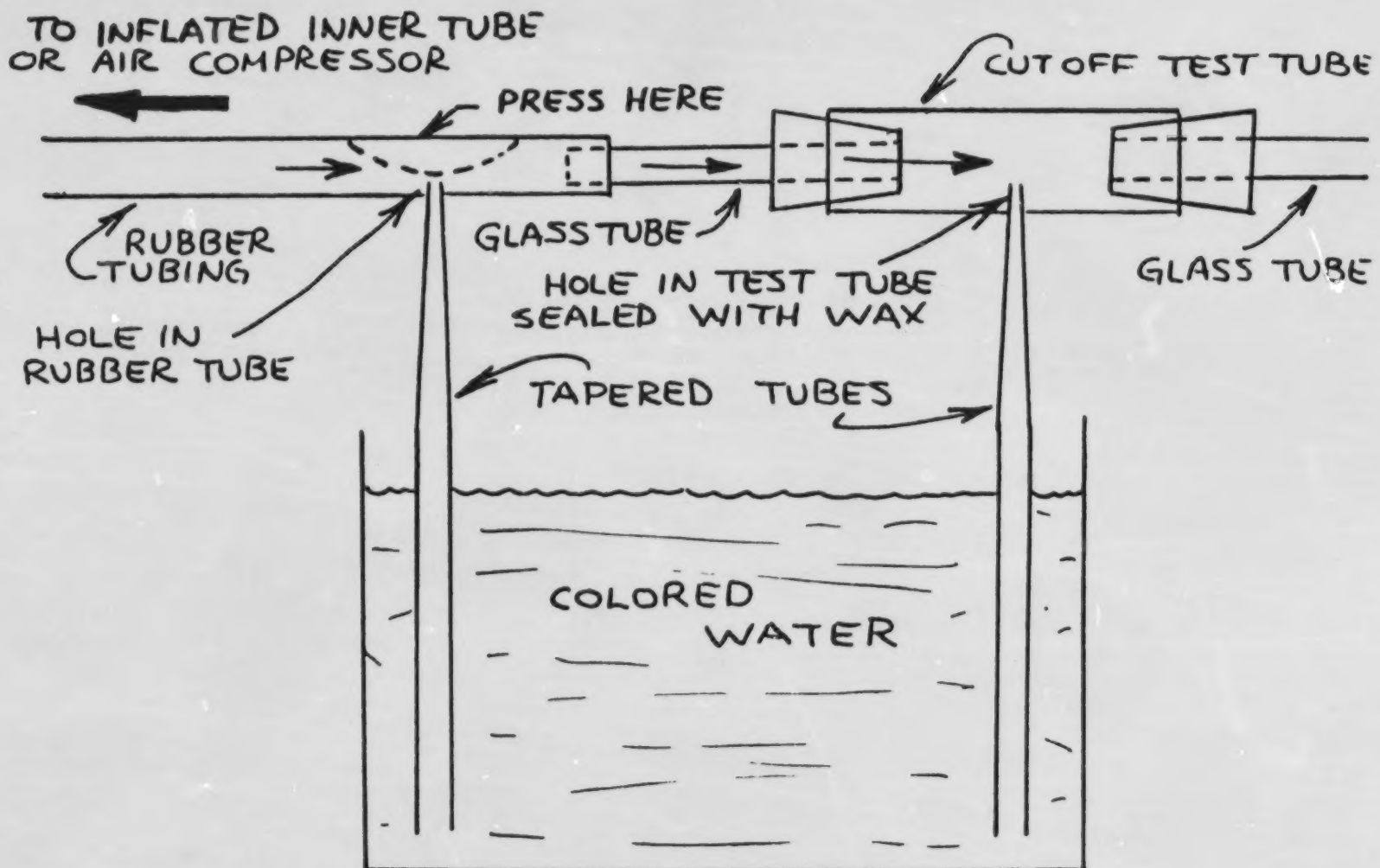
V = Velocity of flow $\left(\frac{\text{ft}}{\text{sec}}\right)$

Note: Try to make measurements as accurate as possible at indicated positions shown below.



CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

TO INFLATED INNER TUBE
OR AIR COMPRESSOR



BERNOULLI'S PRINCIPLE

Title: LAB--Measuring Horsepower with a Simple Prony Brake

Unit: Mechanics

Course: Physics

Purpose:

To be able to calculate the horsepower of motors.

Materials Required:

Two ring stands; clamps; spring balances; pulley.

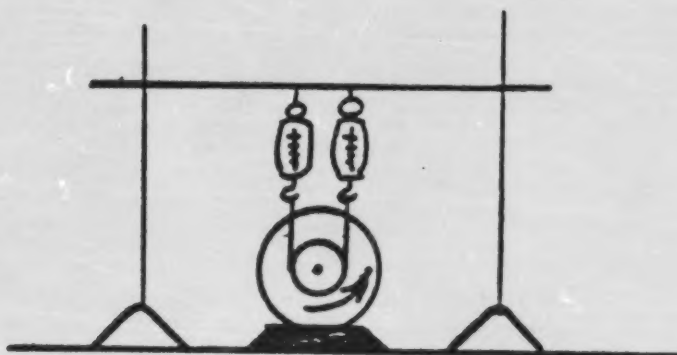
Information:

In this experiment we will calculate the H.P. of several electrical motors (a very small gasoline engine may be used, but you should restrict its size to a model airplane engine).

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Make a simple Prony brake by fastening two ring stands as shown in the following sketch:



Place clamps near the top of each stand and attach spring balances. Half-way between the bases of the ring stands place a small electric motor or model engine whose horsepower is to be tested and place a pulley on its shaft. Connect a thin piece of rope (about $3/16$ " in diameter) between the spring balances so that the rope passes under the pulley. Now adjust the tension on the ropes until both balances have the same reading.

Title: LAB--Measuring Horsepower with a Simple Prony Brake

PAGE TWO

Set the motor or engine into operation. Pull up on one balance until the engine or motor almost stops. Immediately read the force on the two balances. The difference between the two readings is the force exerted by the motor. Measure the diameter of the pulley and multiply it by 3.14 to find the circumference. Divide by 12" to convert it to feet. Then find the rated speed in RPM on the name plate or in the instruction book for the motor or engine.

Multiply the three figures - the force in pounds, the circumference in feet and speed in rpm and then divide by 33,000 foot-pounds per minute to get the horsepower.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: INFORMATION SHEET FOR SPECIFIC GRAVITY EXPERIMENTS

Different substances vary in density, that is to say the particles of matter, of which they are composed, are packed closer together in some than in others. Naturally, denser materials like mercury, steel, and lead, weigh more per unit volume than less dense material like woods and alcohol.

The auto mechanic using a hydrometer to test a storage battery or a radiator is taking advantage of this difference in densities to determine the charge of the battery and the quantity of anti-freeze present in the radiator water. This process is known as determining the specific gravity. The specific gravity of a solid or liquid is the ratio of its weight to the weight of an equal volume of water.

$$\text{Specific gravity} = \frac{\text{weight of substance}}{\text{weight of equal volume of water}}$$

From the above it can readily be seen that if the substance is dense (heavier) than water, the specific gravity will be greater than 1.0 on the other hand, if the density of the substance is less than water, the specific gravity will be less than 1.0. The specific gravity of a dense material like gold is 19.3 which means that a cu. in. of gold weighs 19.3 times as much as a cu. in. of water. Kerosene which is lighter than water, has a specific gravity of .79.

Unit: Mechanics

Course: Physics

Purpose:

To compare the weights of certain liquids with the weight of an equal volume of water; (to determine their specific gravity).

Materials Required:

Platform balance (Laboratory scales); Bottle - 16 oz.; Kerosene; Saturated salt solution; Hydrometer; 3 hydrometer jars (15" x 2").



Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

(Record all readings in data table)

1. Weigh the empty bottle.
2. Fill the bottle with water, level full, and weigh again.
3. Repeat with kerosene.
4. Repeat with salt solution.
5. Determine the specific gravity of kerosene and salt solution by dividing the weight of each by the weight of equal volume of water.

PAGE TWO

6. Check the specific gravity of kerosene, salt solution and water by using the hydrometer jars and hydrometer.

WEIGHT OF BOTTLE EMPTY	
WEIGHT OF BOTTLE PLUS WATER	
WEIGHT OF BOTTLE PLUS KEROSENE	
WEIGHT OF BOTTLE PLUS SALT SOLUTION	
WEIGHT OF WATER WITHOUT BOTTLE	
WEIGHT OF KEROSENE WITHOUT BOTTLE	
WEIGHT OF SALT SOLUTION WITHOUT BOTTLE	
WEIGHT OF KEROSENE $\div$ WEIGHT OF WATER (S.G.)	
WEIGHT OF SALT SOLUTION $\div$ WEIGHT OF WATER (S.G.)	
SPECIFIC GRAVITY OF WATER BY HYDROMETER	
SPECIFIC GRAVITY OF KEROSENE BY HYDROMETER	
SPECIFIC GRAVITY OF SALT SOLUTION BY HYDROMETER	

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Specific Gravity (Objects Heavier than Water)

Unit: Mechanics

Course: Physics

Purpose:

To determine the specific gravity of solid bodies heavier than water.

Materials Required:

Spring balance; piece of cement (dipped in paraffin to make impervious to water); Piece of brass; Piece of aluminum; Jar - 2 quart size.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Weigh the cement block.
2. Weigh the cement block submerged in water.
3. Determine the specific gravity of the cement block by dividing the weight in air by the apparent loss of weight in water.
4. Repeat the experiment using brass and aluminum blocks.

	CEMENT	BRASS	ALUMINUM
WEIGHT IN AIR (w)			
WEIGHT IN WATER (w^1)			
LOSS OF WEIGHT ($w - w^1$)			
SPECIFIC GRAVITY ($\frac{w}{w - w^1}$)			

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Specific Gravity (Floating Bodies)

Unit: Mechanics

Course: Physics

Purpose:

To determine the specific gravity of a floating body.

Materials Required:

Block of wood; spring balance; jar; sinker.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Weigh block.
2. Tie a sinker to a block and weigh with sinker submerged.
3. Take a scale reading with both block and sinker submerged.
4. Determine weight of volume of water equal to the volume of the block.
5. Determine the specific gravity of a block.

1.	WEIGHT OF BLOCK IN AIR	
2.	WEIGHT OF BLOCK IN AIR AND SINKER IN WATER	
3.	WEIGHT OF BOTH UNDER WATER	
4.	WEIGHT OF EQUAL VOLUME OF WATER	
5.	$\text{SPECIFIC GRAVITY} = \frac{\text{STEP 1}}{\text{STEP 2} - \text{STEP 3}}$	

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--How to Make a Hydrometer

Unit: Mechanics

Course: Physics

Purpose:

To make a Hydrometer and be able to use it.

Materials Required:

Three tall beakers; One test tube; lead shot; black magic marker; Bunsen Burner; alcohol antifreeze; water (Car's battery).

Information:

The Hydrometer is an instrument that measures specific gravity of liquids by making use of Archimedes Principle (specific gravity is the ratio between the density of a liquid and the density of water).

The electrolyte in a lead storage battery is a solution of sulfuric acid in water. The specific gravity of the electrolyte in a fully charged cell is about 1.3; that of a discharged cell, around 1.15. In common practice these limits are calibrated on the hydrometer as 1,300 and 1,150. When the cell is discharging water (sp gr=1) is formed and replaces the heavier sulfuric acid, and conversely, as the battery is charged, the concentration of the sulfuric acid increases. Thus by measuring the specific gravity of the electrolyte the condition of charge of the battery can be checked.

Procedure:

- A. Attach a strip of paper to the outside of a test tube with an elastic band.
- B. Insert tube in water and add weights (Lead shot or BB's to the tube so that the tube is upright),
- C. Mark the level of the water on the strip of paper. Give that point a reading of 1,
- D. Make a 50/50 solution of alcohol and water and take your readings. Mark your readings on the strip of paper on the test tube,
- E. Heat a beaker of water and note the reading.
- F. Do the same experiment as above except this time use permanent antifreeze.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Pressure is Proportional to Density

Unit: Mechanics

Course: Physics

Purpose:

To show the effect of pressure and density.

Materials Required:

2 - 4" glass tubes; Small bottle with 2 hole stopper; Colored gasoline or kerosene; Mercury.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

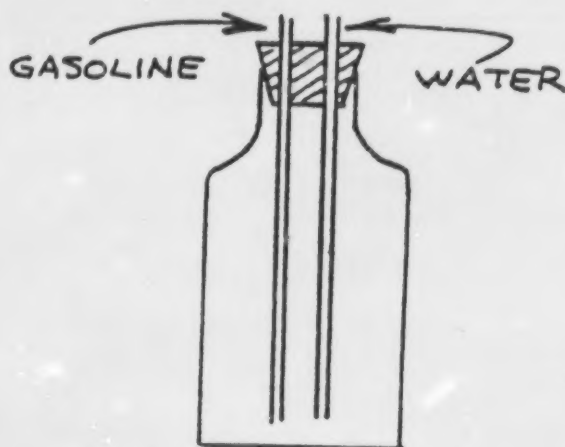
Push glass tubes through stopper so as to almost touch the bottom of the bottle.

Fill the bottle with water.

Put stopper with tubes in bottle.

Pour gasoline in one tube as water is poured in the other until the gasoline tube is filled. Measure the heights of the different liquids in each tube.

Do the same with mercury and water, put the mercury in the bottle first.



CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title. LAB--Pressure is Proportional to Density

PAGE TWO

Questions:

1. The statement Liquids seek their own level is not quite true. What would you add to the statement to make it correct?
2. Explain why the pressure of liquid in each tube, where it meets the level of the liquid in the bottle, is the same.
3. Explain why the difference of heights of the liquids in the tubes would be the ratios of their densities.

Title: LAB--Pressure is Proportional to Depth

Unit: Mechanics

Course: Physics

Purpose:

To show that pressure increases as depth of water increases. Also, to show that the force is equal to the product of pressure and area.

Materials Required:

Inner tube and bicycle tube; Small book; Toy balloon; 2" - 4" lengths of glass tubes; Glass "Y"; Glass funnel; 12" rubber tube; Elastic band; Drafting board; Rod support with clamps.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

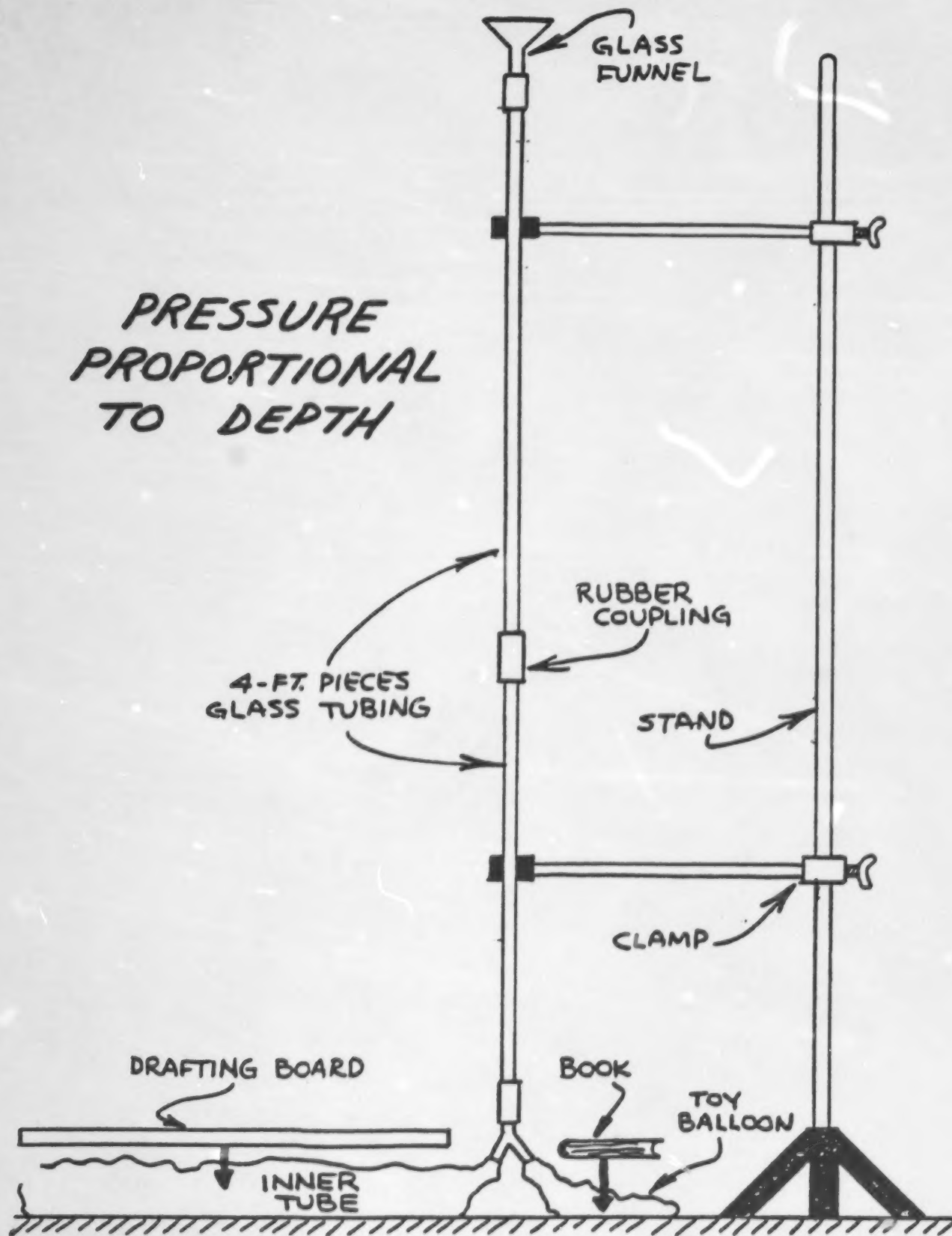
1. Remove valve from inner tube.
2. Half fill the tube with water.
3. Half fill the balloon with water.
4. Connect as shown.
5. Place board and book on the tube and the balloon.
6. Note level of water (record).
7. Place heavier weights on each, one at a time, note water level.
8. Stand on board while water is added to funnel. Remove balloon.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Questions:

1. Explain why the pressure in the tube was increasing when the water level increased.
2. Could the weight of your body be lifted by the weight of the water in the glass tube? Explain why.
3. Why doesn't the balloon lift an equal weight?

PRESSURE PROPORTIONAL TO DEPTH



Title: LAB--Compressibility of Liquids and Gases

Unit: Mechanics

Course: Physics

Purpose:

To show that liquids are not compressible and gases are.

Materials Required:

3/8" I.D. rubber tubing 3' long; 2 long pieces of 3/8" dia. chalk.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

Fill sink with water.

Put tube in water to fill tube (carefully).

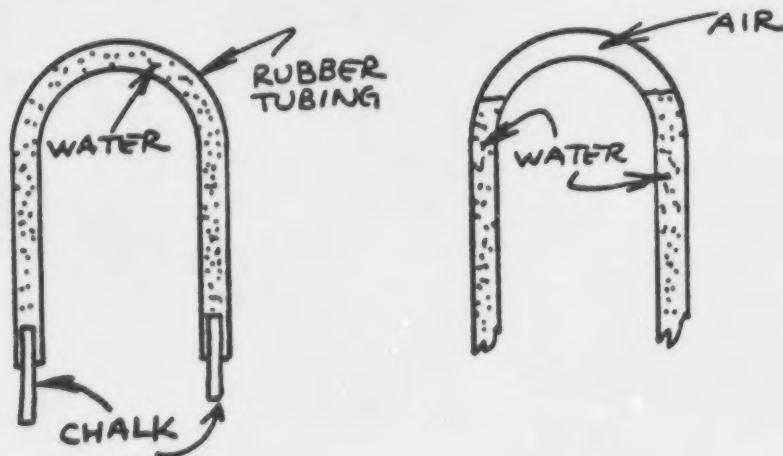
Put chalk in one end flush.

Push chalk in other end slowly (watch results).

Remove some water from the tube.

Repeat with both pieces of chalk as above (observe).

Try with different amounts of air in tube.



CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Questions:

1. Was the distance one piece of chalk was pushed in, the same as the distance the other piece of chalk was pushed out? Was this the same at all times.
2. Explain what happens when very little air was in the tube as compared with very much.
3. What conditions would exist in the tube which would be similar to spongy brakes.

Title: LAB--The Hydraulic Press

Unit: Mechanics

Course: Physics

Purpose:

To demonstrate the use of a hydraulic press, or jack, also to prove Pascal's Law.

Materials Required:

2 Straight wall lamp chimneys or
2 2" diameter clear plastic tubes with a two-hole stopper fitted with two glass tubes as shown; 2 Corks to fit the glass tubes; a tube of pliobond; a 2-1/2" diameter flap of rubber sheeting.

Information:

Pascal's principle states that pressure applied to a confined fluid is transmitted undiminished in all directions. This pressure acts at right angles to the container and exerts equal forces on equal areas.

The amount of pressure depends on the Force applied and the area of the piston.

In most hydraulic applications, round cylinders are used. This cylinder may be described by its radius or diameter.

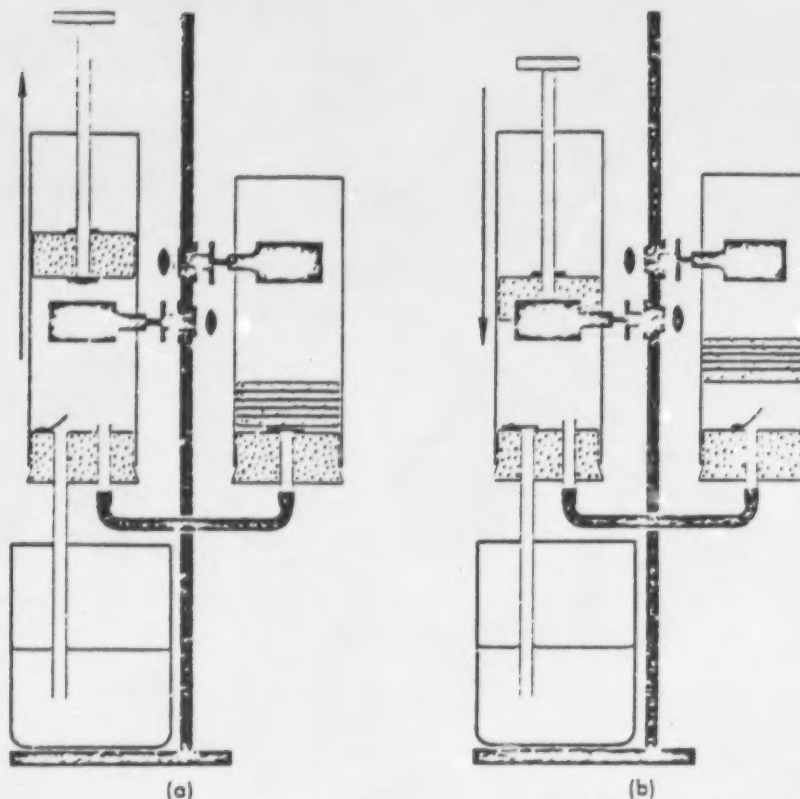
The formulas for the area of a circle are $A = \pi r^2$; $A = 1/4 \pi d^2$.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY, DO YOUR OWN WORK, KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

For the piston, select cork that is slightly smaller than the internal diameter of the tube. Wrap some waxed soft cotton cord around the cork so that it fits inside the tube snugly but can slide back and forth. Now drill a hole 1/4" in diameter in the center of the cork and cement a dowel rod of the same diameter into it. A good cement to use is Pliobond which is hot-water soluble, will bond to glass, and has some flexibility. Finally, make a rubber flap valve over the two-hole stopper by tacking a small square of rubber sheeting over one of the holes on the end of the stopper that will go inside the tube.

Then assemble the lifting section of the jack or press by setting up a second glass or plastic cylinder fitted with a cork and dowel piston like the one already described. The bottom of this cylinder should also contain a one-holed stopper equipped with a short glass and a flap valve. Now connect the glass tube without the valve of the first cylinder to the glass tube of the second cylinder (the lifting section) with rubber tubing. Then place the down-tube of the first cylinder in water as shown and operate the dowel handle. On the upstroke, students should see that water enters the first cylinder. On the downstroke, the valve closes and water is forced into the second cylinder where it lifts the piston.



Model of a hydraulic press: (a) on the upstroke, (b) on the downstroke.

Calculate the amount of pressure in the apparatus by using the following formula:

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

Force can be measured by, placing a set of numbered weights on top of the piston and noting how many it takes for the water in the first cylinder to empty. Area can be calculated using the pistons area. Pressure can then be calculated by dividing area into the force.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR: INSTRUCTOR'S INITIALS _____

Title: LAB--Boyle's Law

Unit: Mechanics

Course: Physics

Purpose:

To show that if the temperature remains the same, the volume of a gas varies inversely to its pressure.

Materials Required:

4 bottles; 4 - 2 holed stoppers; 6 glass elbows; 4 short rubber tubes; 4' glass tube; glass tee; 12' rubber tube; 5 rubber tube clamps.

Information:

According to Boyle's Law, under isothermal conditions (meaning conditions of a constant temperature), pressure and volume of a given mass of a gas are inversely proportional. ($p = m/vol$, thus p is inversely proportional to volume. Boyle's Law could be stated as follows: Under isothermal conditions pressure and density of a gas are directly proportional or $Vol \propto 1/P$). The mathematical symbol for proportion is $\propto$.

Procedure:

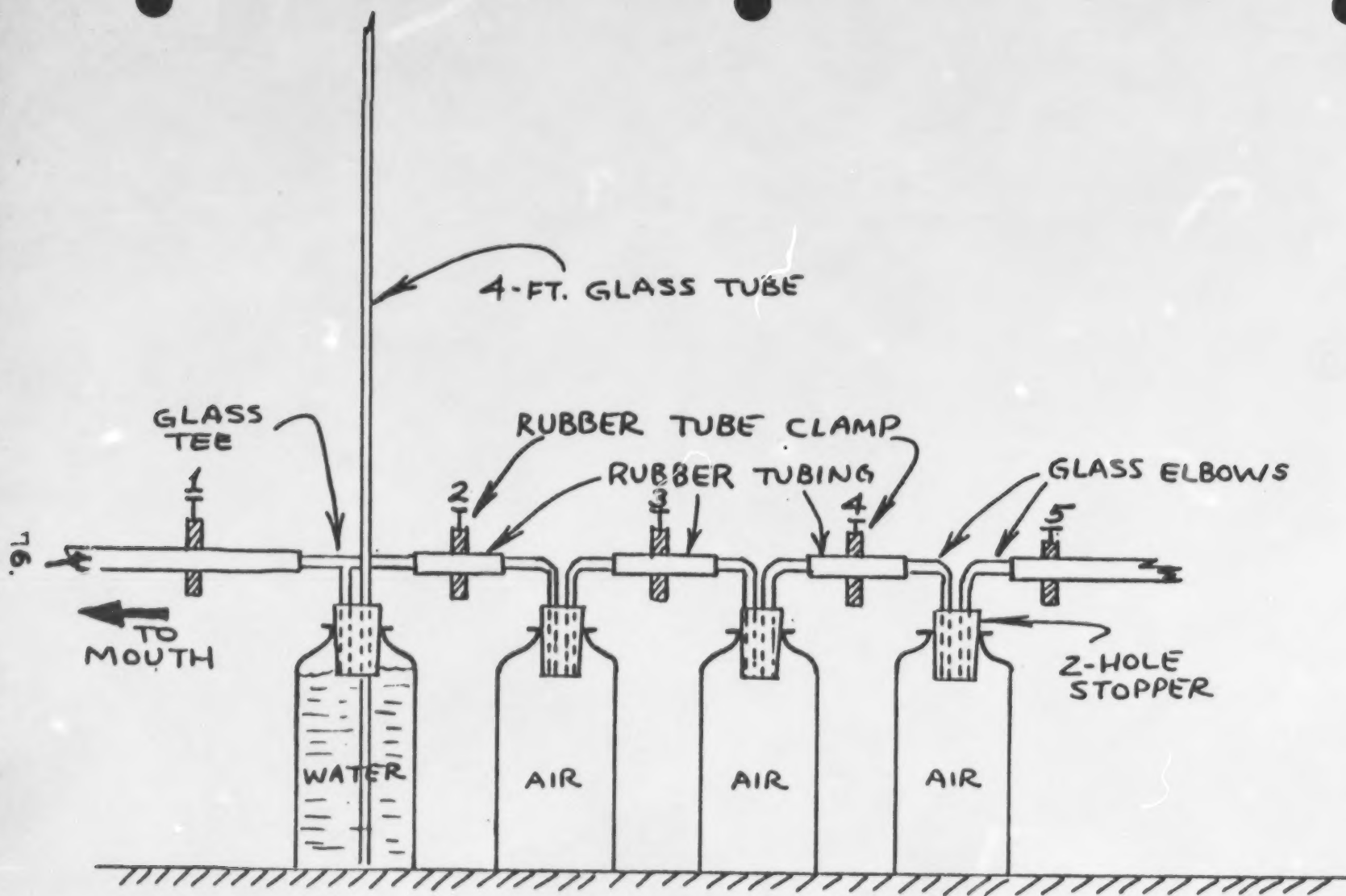
FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Insert glass tee, elbows and rod in stopper, as illustrated.
2. Fill first bottle with water.
3. Connect with rubber tubes.
4. Clamp #2 and blow to have water reach top of 4' glass tube, then clamp #1.
5. Clamp #3 and remove #2, note height.
6. Clamp #4 and remove #3, note height, etc.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Questions:

1. As you doubled the volume what happened to the height?
2. Explain why difference in height is directly related to difference in pressure.
3. Explain why the pressure is decreased when the piston is moving in a down stroke.
4. Explain why it is increased in an up stroke.
5. If one bottle is heated and allowed to cool what effect would it have on the level of the water in the tube? How would it affect the pressure?



BOYLE'S LAW APPARATUS

Title: LAB--Combustion of Gasoline

Unit: Mechanics

Course: Physics

Purpose:

To show the change of potential energy to kinetic energy.

Materials Required:

Can and cover; spark plug; wires; gasoline; coil and battery or magneto; atomizer.

WARNING: USE EXTREME CARE WHEN PERFORMING THIS LAB BECAUSE OF THE USE OF GASOLINE.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

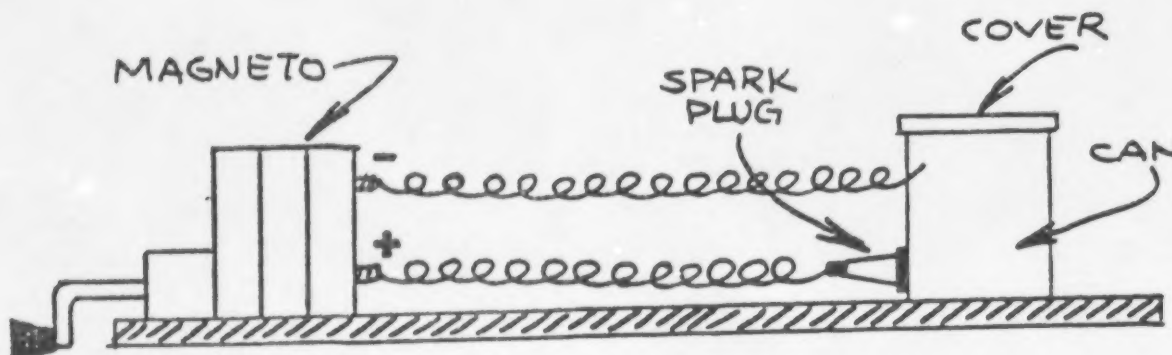
Make a hole in a can for a spark plug.

Attach plug to can.

Wire assembly.

Insert gasoline in can with atomizer.

Charge plug. (Caution).



CLEAN UP YOUR WORK STATION,
DIRECTED BY YOUR INSTRUCTOR.

BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS
INSTRUCTOR'S INITIALS _____

Title: LAB--Combustion of Gasoline

PAGE TWO

Questions:

1. Was the explosion the same with different amounts of gasoline?
2. How could you get better vaporization?
3. What results demonstrate kinetic energy?
4. What part of this experiment is potential energy?
5. What device on an engine controls the mixture?

Title: LAB--Combustion of Gasoline

INSTRUCTOR'S NOTES

In the interest of safety, this lab should be performed as a demonstration.

COMMENTS:

HEAT

Title: LAB--Heat Conductivity of Metals

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To compare the heat conductivity of various metals.

Materials Required:

Metal strip samples and wax indicators (as many as designated by your instructor); ring stand; ring stand clamp; bunsen burner; striker; apron; eyeshield.

Information:

There is a wide variation in heat conductivity from one metal to another. Thermal or heat conduction seems to depend on three things: 1) atoms and molecules being agitated by heat and actually vibrating against each other and mechanically passing along the heat energy; 2) thermal radiation between neighboring molecules having a similar result; and, 3) the activity of electrons.

By combining metals with different heat conductivities, for example, pots or pans can be made to heat evenly and quickly where the food is cooked while the handles remain relatively cool. Heating and refrigerating units can be made more efficient by using metals having the correct heat conductivity for the different parts.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. KEEP YOUR WORK STATION CLEAN AND IN ORDER AT ALL TIMES. PRACTICE SAFETY. DO YOUR OWN WORK.

1. Set up the ring stand and clamp. Adjust the jaws of the clamp to hold something horizontally.
2. Mount two strips of different metals, as designated by your instructor, in a V-shape, horizontally, by fastening one end of each in the clamp (in other words, one end of each metal should be clamped together while the other end is spread apart giving the V-shape).
3. Place four pieces of the wax indicator on each sample at about 2-inch intervals. INSTRUCTOR'S INITIALS _____.
4. Set up and light the bunsen burner. Be certain that it has a clean flame.
5. Apply heat from the burner flame evenly to the clamped ends of both strips.

Title: LAB--Heat Conductivity of Metals

PAGE TWO

6. Observe the progress of heat along each strip as the wax indicators melt. Which is the better heat conductor? Record your results.
7. Repeat the procedure for various other sets of metals, as designated by your instructor. Be certain to allow samples in previous test to cool before handling.
8. Prepare a chart or list, as directed by your instructor, to show the conductivities of the various samples.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Trade Relatedness:

1. Explain whether, and why, high or low heat conductivity is desirable in
 - An automobile radiator
 - A metal window sash
 - A soldering iron
 - A water-heater coil
 - A baseboard radiator
 - Home insulation
 - A styrofoam cooler
2. Why is some cookware "copper-clad"? Explain.
3. Why are many coal or wood burning stoves made of cast iron? Explain.
4. What is the difference between a heat conductor and a heat insulator? Explain.

Title: - LAB--Heat Conductivity of Metals

INSTRUCTOR'S NOTES

Strips for testing should be about 8 inches long and 1 inch wide (the thickness should be the same). The strips may be obtained from the school metal shops or from local industry (trimmings, etc.).

A variety of samples should be tested such as stainless steel, low-carbon steel, copper, aluminum, etc.

Wax indicators can be made from 1/8-inch cubes of paraffin or from slices of wax crayons.

Another variation for this lab, uses wire rather than strips for testing. The wire samples are twisted together at one end while the other end is fanned out. Wax is looped around the wire every couple of inches to act as an indicator. Heat is applied to the twisted ends of the wires and conduction is observed by the melting of the wax indicator

COMMENTS:

Title: LAB--Insulation

Unit: Heat

Course: Physics

Purpose:

To test the insulating qualities of various materials.

Materials Required:

Various "insulating" materials (such as fiberglass, sawdust, sand, expanded styrene beads, steel wool, etc.); 3 tin cans of varying sizes (such as 6 oz. tomato paste can, 15½ oz. vegetable can, and 29 oz. tomato puree can); hot plate (or other similar heat source); blocks of wood, 2 thermometers; asbestos mitts; clock or other timing device.

Information:

An insulating material is a non-conducting substance used to prevent the passage or leakage of heat. The effectiveness of the insulation depends a great deal on the insulating material itself--its composition, its durability, its thickness, its conductivity, etc. Of course, proper installation is also a key factor.

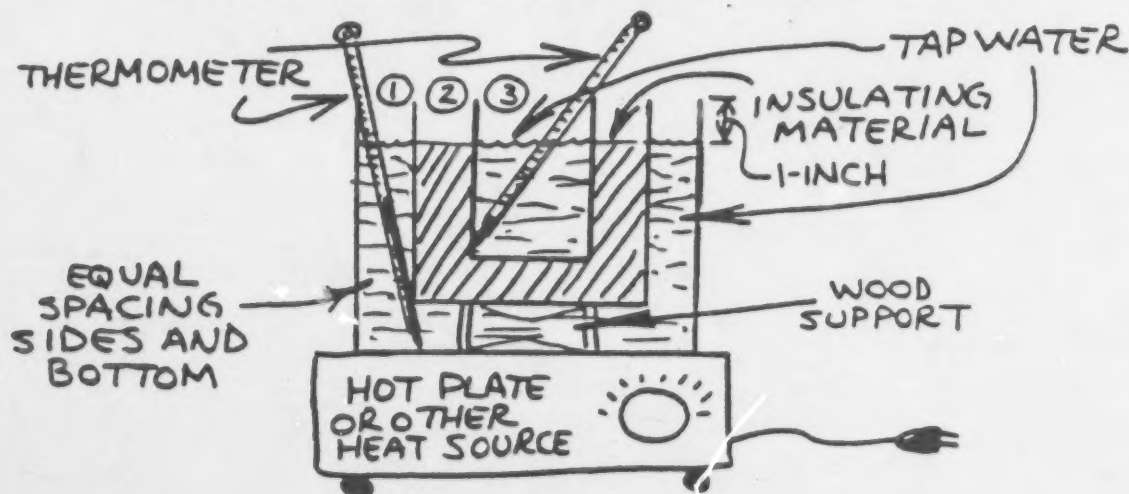
Insulation is used in stoves, refrigerators, freezers, hot water heaters, ice chests, thermos jars, and other items. Perhaps its best known use is for home insulation. Here it is used to hold heat in during the cold winter months and to keep heat out during the warm summer months. In this respect it helps to conserve energy while helping to maintain comfort.

Various materials are utilized for insulating against heat transfer. They include fiberglass, styrofoam, balsam wool, trapped air, and others.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. KEEP YOUR WORK STATION CLEAN AND IN ORDER. DO YOUR OWN WORK. PRACTICE SAFETY AT ALL TIMES.

1. Set up the apparatus as indicated in the diagram below:



Title: LAB--Insulation

PAGE TWO

2. In the space below, prepare a set of tables to record your data. (Your instructor will indicate how many materials you will be testing). The tables should be set up to indicate the material tested, the initial and final temperatures of the water in cans 1 and 3, the time to raise the temperature of water in can 3, and the average time for three trials. INSTRUCTOR'S INITIALS _____.
3. Record the starting temperature of the water in cans 1 and 3 in the table you prepared.
4. Begin heating and start timing. Stir the water in both cans gently with the thermometers while heating. Continue heating until the temperature of the water in can 3 (the center can) has been raised about $5\frac{1}{2}^{\circ}\text{C}$ (10°F).
5. Record the final temperatures of the water in cans 1 and 3 in the table, along with the time it took to raise the temperature of water in can 3 the desired amount.

Title: LAB--Insulation

PAGE THREE

6. Continue heating, allowing the water in the can 3 to increase another $5\frac{1}{2}^{\circ}\text{C}$. This is trial 2. Record the time and temperatures in the table.
7. Continue heating as indicated in step 6, above. This is trial 3.
8. Carefully disassemble the apparatus--It may be hot. If indicated by your instructor, replace the insulating material with a different sample and replace the water in both cans with fresh tap water at the same temperature. Repeat the procedure, described above, for the new material.
9. Compare the results of your test of the materials. What generalizations do you make?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT EVERYTHING IS PLACE AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. Why are homes that are insulated less expensive to heat than those that are not? Explain.
2. Explain why insulation is used in the following items
A refrigerator
An oven
A hot water heater
3. What difference is there between an insulating material that is packed firmly and one that is packed loosely? Explain.
4. What does "R" value mean? Explain.
5. What is weather stripping? Why is it used? Explain.
6. What is a thermal break? Explain.
7. How does an insulating glass, such as Thermopane, get its insulating qualities? Explain.

Title: LAB--Linear Expansion

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To measure the coefficient of linear expansion of various specimens.

Materials Required:

Linear expansion apparatus; test rods or tubes; steam boiler; rubber delivery tube; tripod (or ring stand and ring); bunsen burner; striker; meter stick; thermometer; beaker (to collect condensate) or rubber tubing (to direct condensate to sink); apron; eyeshield; asbestos mitts; water.

Information:

Nearly all substances expand when heated and contract when cooled. To predict how much a material will expand or contract, use is made of the COEFFICIENT OF LINEAR EXPANSION. It is the change in length of a unit of length of a solid when undergoing a temperature change of one degree.

$$\text{coefficient of linear expansion} = \frac{\text{change in length}}{\text{original length} \times \text{change in temperature}}$$

Linear expansion can be very critical in many areas and must be considered. For example, in the construction of a bridge, with large steel beams, one end of the beam is attached firmly while the other end is attached to a roller or rocker assembly. This permits movement of the beam as temperature changes (and so does the expansion and contraction of the beam). On very large bridges, one may notice large finger-like devices across the travelway. These are called "expansion dams" and they are stalled to permit the bridge to expand and contract freely without any structural harm.

In the installation of pipes, especially those that may carry water at various temperatures, provisions have to be made for movement. Support brackets, sleeves, etc. must be made loose enough to permit the pipe to move freely as expansion and contraction takes place. If this is not considered, the pipe may buckle or joints may open.

Often when there is a fire in a so-called fireproof building, one hears about "structural damage". This does not mean that the building has collapsed but that perhaps the intense heat of the fire caused beams to expand to a point where sidewalls may have failed or they expanded beyond their limit and have become twisted or distorted themselves.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP, DO YOUR OWN WORK, KEEP YOUR WORKSTATION CLEAN AND IN ORDER, PRACTICE SAFETY AT ALL TIMES.

Title: LAB--Linear Expansion

PAGE TWO

1. Since devices for determining the coefficient of linear expansion vary, and so do the methods for measuring the amount of expansion, your instructor will diagram the apparatus you will be using and explain how to make the necessary measurements.

Draw a simple diagram of the apparatus you will be using (be certain to clearly label all the parts.)

Explain by words, or simple sketches, how you will measure the amount of expansion--

2. Set up the apparatus as indicated by your diagram, above, and have it checked by your instructor. INSTRUCTOR'S INITIALS _____.
3. Record the following data
Material of rod or tube
Original length of rod or tube
Initial temperature of rod or tube
4. Heat the water in the boiler and allow the steam to pass through the tube or around the rod until no further expansion is indicated (this usually requires the flow of steam from 4 to 5 minutes).
5. Record the following data
Final temperature of rod or tube
Elongation (change in length of rod or tube)
6. Turn off heat for boiler. Allow apparatus to cool.

Title: LAB--Linear Expansion

PAGE THREE

7. Calculate the coefficient of expansion using the formula mentioned under "Information" on Page One. Show your calculations here--
8. Compare your experimental value of the coefficient against the accepted value. Are they different?
List some possible errors in this lab that may account for the difference if there is one--
9. If indicated by your instructor, repeat this procedure for a rod or tube of a different material. Show all the data and calculations as before.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. Explain how a bi-metallic strip in a thermostat operates,
2. What effect does temperature have when making measurements with a steel tape measure? Explain fully.
3. What effect does temperature have on steel or aluminum siding? What precautions should be taken? Explain.
4. What effect does temperature have on plastic water pipe, such as PVC? What installation precautions should be taken? Explain.
5. Explain why Pyrex glass is used for cooking or baking while ordinary glass is not.

COEFFICIENTS OF LINEAR EXPANSION
(Per Degree Centigrade)

Aluminum	0.000025
Brass	0.000019
Copper	0.000017
Glass, Pyrex	0.000004
Glass, ordinary	0.000009
Invar	0.0000009
Iron	0.000011
Lead	0.000028
Platinum	0.000009
Quartz	0.000005
Silver	0.000019
Steel	0.000013
Tungsten	0.0000043
Zinc	0.000026

Title: LAB--Linear Expansion

INSTRUCTOR'S NOTES

The apparatus for measuring linear expansion varies. For this reason, no apparatus diagram was included. It is left to the instructor to diagram the apparatus that will be used by the student. It is also left to the instructor to explain the method for measuring expansion, since this also varies with each apparatus. Provisions are made on the lab sheet for students to record this information.

If the boiler is not equipped with a thermometer, have the student assume the final temperature of the rod or tube to be 100°C .

COMMENTS:

Title: LAB--Boiling

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To observe how the boiling point of water is affected by pressure and the presence of dissolved solids.

Materials Required:

250-ml Erlenmeyer flask with 2-hole rubber stopper; tripod (or ring stand and ring); thermometer; bunsen burner; striker; wire gauze; 2 pieces right angle glass tubing (for delivery tube); rubber tubing; hydrometer jar; water (with low mineral content); sodium chloride (or table salt); asbestos mitts; apron; eyeshield; vacuum pump; 250-ml beaker; triple beam balance.

Information:

Boiling is essentially rapid evaporation. Although evaporation occurs at all temperatures, boiling occurs only at a fixed temperature--the boiling point. The boiling point of any liquid is the temperature at which its vapor pressure equals atmospheric pressure.

Vapor pressure is the pressure exerted on a liquid and the air above it by the escaping molecules of the liquid. Raising the temperature raises the vapor pressure. Increasing the atmospheric pressure on the surface of the liquid requires an increase in the vapor pressure for the liquid to boil. It follows, then, that increasing the pressure on a liquid raises its boiling point (of course, decreasing the pressure lowers the boiling point).

The presence of dissolved minerals in water also effect the boiling point. Dissolved salts and other minerals do not readily vaporize and generally cause an increase in the boiling point.

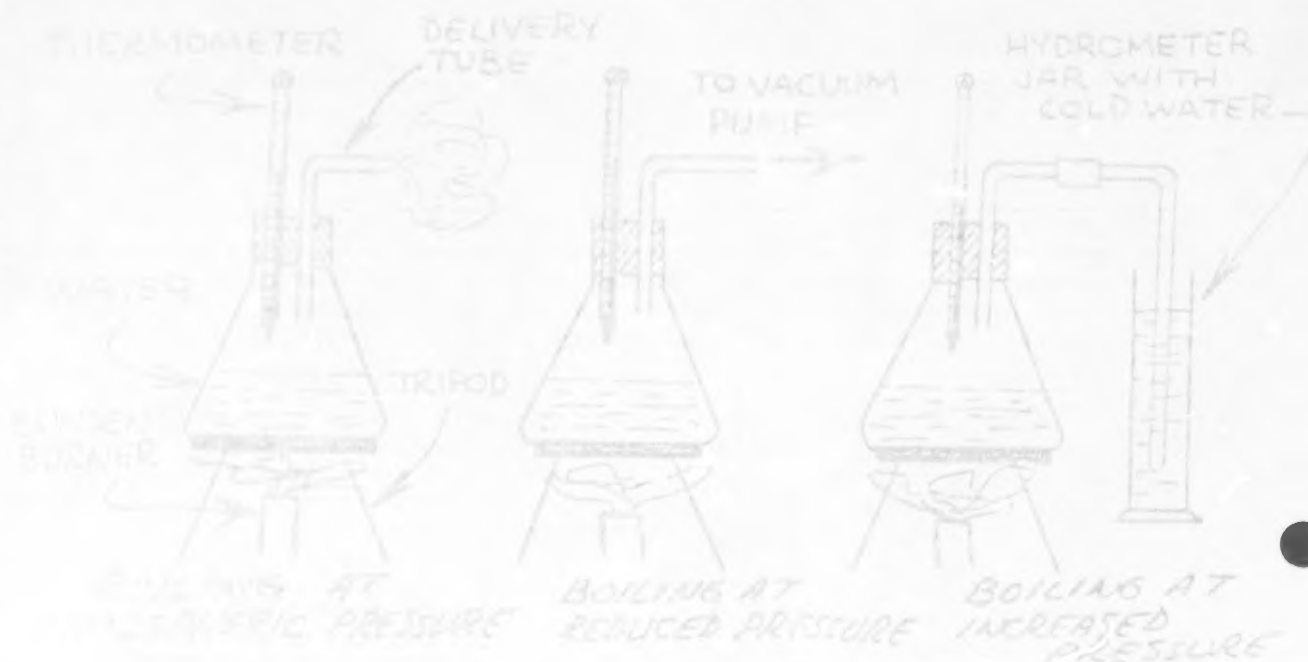
Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP, DO YOUR OWN WORK, KEEP YOUR WORK STATION CLEAN AND IN ORDER, PRACTICE SAFETY AT ALL TIMES.

1. CAREFULLY place piece of right angle glass tubing into one hole of the stopper. CAREFULLY place the thermometer into the remaining hole of the stopper. Refer to diagram on the following page.
2. Fill the Erlenmeyer flask about one-third full of water. Place the stopper on the flask and adjust the thermometer so that its bulb is about 3 centimeters above the surface of the water. In this position, the thermometer will indicate the temperature of the _____. Be certain that the delivery tube is not in the water.

INSTR. 74

1. Set up the tripod and ring stand and flask and the burner for a boiling operation. DO NOT LIGHT THE BURNER until directed by your instructor. Place the flask on the tripod. INSTRUCTOR'S INITIALS _____



1. Add water to boiling. Watch carefully. Watch the thermometer and note the temperature at which the mercury stopped rising. The temperature is _____. Insert the flask so that it is just below the surface of the water. Note the temperature. The temperature is _____.
2. Turn off the burner. Allow flask to cool. CAREFULLY remove stopper and add enough water to the flask so that the bulb of the thermometer is just below the surface of the water. In this position the thermometer will indicate the temperature of the _____. Be certain that the delivery tube is not in the water. INSTRUCTOR'S INITIALS _____
3. Refill the water. Allow to boil vigorously. Watch the thermometer as before and record the proper temperature. The temperature is _____.
4. Turn off burner. Allow flask to cool. CAREFULLY remove stopper and add enough water to the thermometer bulb so that it is again just below the surface of the water. INSTRUCTOR'S INITIALS _____

PAGE THREE

9. Shut off burner. Allow flask to cool. CAREFULLY remove vacuum hose from delivery tube. Fill hydrometer jar with water. Attach second piece of right angle glass tubing to the delivery tube with a small section of rubber tubing. Refer to diagram on Page Two.
10. Leave the outlet (delivery tube) open to the atmosphere and again heat the water to boiling. Note the temperature. Submerge the opening in the outlet in the hydrometer jar with water. Record the boiling point. The temperature change should be small but noticeable. The temperature is _____.
11. Shut off burner and allow flask to cool. CAREFULLY remove stopper and detach second piece of glass tubing. Empty flask. Fill flask two-thirds full of water and dissolve about 8.75 grams (2 teaspoonfuls) of sodium chloride (table salt) in it. Pour some of the solution into a beaker so that the bulb of the thermometer will again be 3 cm above the surface of the solution. Save the solution in the beaker.
12. Boil the water in the flask, leaving the delivery tube open to the atmosphere. The temperature is _____.
13. Allow flask to cool and add more solution from the beaker so that the bulb of the thermometer is just covered as before. Once more, heat to boiling and record the temperature. The temperature is _____.
14. While the apparatus is cooling, answer the following questions:
When the bulb of the thermometer was above the surface of the water, it indicated steam temperature; when the bulb was submerged in the water, it indicated the temperature of boiling water. How did the two temperatures compare? Explain.

Was there any difference between the temperature of slowly boiling water and that of rapidly boiling water? Explain.

When the delivery tube was open to the atmosphere, the water was at atmospheric pressure. When the delivery tube was attached to the vacuum pump it was at less than atmospheric pressure. Finally, when it was placed in the hydrometer jar, it was at greater than atmospheric pressure. Compare the effect of pressure on the boiling point of water.

Title: LAB--Boiling

PAGE FOUR

What effect did the addition of salt have on the boiling point of water? Explain

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACE AS INDICATED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. What is the purpose of a safety valve on a steam boiler? Explain.
2. What is a pressure cooker? How does it work? Explain.
3. What effect does altitude have on the boiling point of water? Explain.
4. The directions on a box of spaghetti included the following--"Salted water takes longer to boil. Add salt after water is boiling to save energy". Is this statement correct? Explain.
5. What effect does pressure have on a refrigerant? Explain.
6. Why shouldn't containers with volatile substances be stored in hot areas? Explain. How can the problem be overcome?

Title: LAB--Boiling

INSTRUCTOR'S NOTES

Glass beads or chips may be placed in flask to reduce chance of stopper blow-out.

If no vacuum pump is available, have the student attach short length of rubber tubing to delivery tube. Boil water in flask with delivery tube open to atmosphere. Remove burner and close tubing with pinch clamp when steam stops issuing from the tube. Cover flask with cold wet towels to condense the steam and produce a vacuum.

COMMENTS:

Title: LAB--Evaporation

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To study the temperature change produced by evaporation of some liquids.

Materials Required:

Thermometer, cheesecloth (or absorbent cotton); string (or rubber bands); beaker; water; alcohol; ether.

Information:

The process by which the molecules of a liquid leave and change to a gas or vapor is known as vaporization or evaporation. A gas can also be formed from a solid state. This process is called sublimation and the solid goes directly into the gaseous state (without becoming a liquid).

Many factors affect the rate of evaporation. They include (1) temperature, (2) surface area exposed, (3) degree of saturation of space above the liquid, (4) circulation in the space above the liquid, and (5) volatility of the liquid.

Evaporation is a cooling process. The cooling results from the fact that the escaping molecules remove energy from the liquid, leaving behind only the slower moving molecules which are at a lower temperature.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Place some water in a beaker. Determine the temperature of the water. The initial temperature of the water is _____.
2. Wrap the bulb of the thermometer with cheesecloth (or absorbent cotton), secure with string (or rubber bands). Dip the covered bulb of the thermometer in the water. CAREFULLY wave the thermometer in the air for about 2 minutes, then quickly read the temperature. The final temperature of the water is _____.
3. The difference between the two readings is _____. Did the temperature increase or decrease after waving?
Why do you wave the thermometer?
4. Repeat the procedure, using alcohol instead of water.
Initial temperature _____
Final temperature _____
Difference _____
Increase or decrease _____

Title: LAB--Evaporation

PAGE TWO

5. Repeat the procedure using ether instead of water. CAUTION--DO NOT INHALE ETHER. BE CERTAIN THAT THE ROOM IS WELL VENTILATED. BE CERTAIN THAT THERE ARE NO FLAMES IN THE LAB.

Initial temperature _____
Final temperature _____
Difference _____
Increase or decrease _____

6. Wrap the bulb again. Leave the wrapping dry. Record the initial temperature, then wave as before and record the final temperature. Repeat again, without any wrapping on the thermometer.

	With dry wrapping	With no wrapping
Initial temperature	_____	_____
Final temperature	_____	_____
Difference	_____	_____
Increase or decrease	_____	_____

7. Compare the data. Which liquid produced the biggest change in temperature? Explain why.

How do you know that the evaporation of the liquid and not the waving caused the temperature change?

Were there any differences in the readings between the thermometer with dry wrapping and the one with no wrapping? If there was, can you explain why?

CLEAN UP YOUR WORK STATION. PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR.
INSTRUCTOR'S INITIALS _____

Trade Relatedness:

1. Explain why in industrial processes that require evaporation large flat pans are employed rather than narrow deep pans.
2. Explain why paint dries faster on a windy day and slower on a humid day.
3. What is meant by a volatile liquid? Explain fully.
4. Explain how perspiration cools the body.

Title: LAB--Evaporation

PAGE THREE

5. How does a refrigerator cause cooling? Explain.
6. How do so-called cleaning solvents work? Explain.
7. Why should gasoline be stored in special containers? Explain.
8. Explain how a sling psychrometer works.
9. Explain how an electric clothes dryer works.

Title: LAB--Evaporation

INSTRUCTOR'S NOTES

In place of waving the thermometer, the student may use a piece of cardboard as a fan and wave the cardboard to promote the circulation of air. If available, an electric fan can also be used.

COMMENTS:

Title: LAB--Heat of Fusion

Unit: Heat

Course: Physics

Purpose:

To determine the heat of fusion of ice.

Materials Required:

Calorimeter can; thermometer; triple beam balance; warm tap water; ice (crushed or cubes); paper towel.

Information:

When a substance gains or loses heat energy, the internal energy of the substance changes. This internal energy change may result in (A) a change in the kinetic energy of the molecules, producing an increase or decrease in temperature, (B) a change in the potential energy of the molecules, producing a change in state or phase, or (C) both kinetic and potential energy changes.

To melt ice at 0°C , heat must be added. This additional heat produces water also at 0°C . The heat energy added to the ice does not appear to increase the kinetic energy of the molecules since there is no increase in temperature. Instead, the heat energy produces a change in phase or state from a solid to a liquid.

The amount of heat necessary to change a substance at its freezing point from a solid to a liquid is called its HEAT OF FUSION or LATENT HEAT OF FUSION.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Weigh the calorimeter can. The mass is _____.
2. Fill the calorimeter can about half full of warm tap water. Weigh the calorimeter can and tap water. The total mass is _____. Subtract the mass of the calorimeter can (see Step 1) from this total mass. The result is the mass of _____. Its mass is _____.
3. Measure the initial temperature of the warm water in the calorimeter. Note that this is also the initial temperature of the calorimeter can. The temperature is _____.
4. Dry a few small pieces of ice with a paper towel. Place the ice in the calorimeter can and gently and continuously (to aid heat transfer) until all the ice has melted.

Title: LAB--Heat of Fusion

PAGE TWO

5. Watch the thermometer. The lowest temperature reached by the mixture is the final temperature. The temperature is _____.
6. Weigh the calorimeter can and its contents. The total mass is _____. Subtract the total mass in Step 2 from this total mass. The result is the mass of _____. Its mass is _____. INSTRUCTOR'S INITIALS _____.
7. The material of the calorimeter can is _____. Its specific heat is _____. The specific heat of water is _____.
8. Calculate the temperature change of the calorimeter can and warm water. The change is _____. Calculate the temperature change of the water formed from the melted ice. The change is _____.
9. According to the Law of Heat Exchange, the total heat lost equals the total heat gained. The total heat lost by the warm tap water in cooling from its initial to its final temperature and the calorimeter can in cooling from its initial to its final temperature is equal to the total heat gained by the ice at 0°C melting to water at 0°C and the water formed from the melting ice at 0°C warming up to the final temperature. Using the equation $\Delta H = m S \Delta T$, calculate the following (be certain to show all work in a neat, orderly fashion):

The heat lost by the warm water--

The heat lost by the calorimeter can--

The total heat lost--

The heat gained by the water from the melting ice--

10. Subtract the heat gained by the water from the melting ice from the total heat lost. This is the total heat of fusion. The value is _____. Divide this value by the number of grams of ice used in this lab. The result is the heat of fusion for 1 gram of ice. The heat of fusion is _____. Compare this result with the accepted value of the heat of fusion of ice. The accepted value is _____. The difference between the accepted value and experimental value is _____. Explain why there may have been a difference--

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT EVERYTHING IS PLACE AS DIRECTED
BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. What practical use do we make of the latent heat of fusion of ice?
Explain.

Title: LAB--Heat of Fusion

INSTRUCTOR'S NOTES

Be certain to remind the students that all references to weighing the calorimeter can refer to its inner cup.

COMMENTS:

Title: LAB--Heat of Vaporization

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To determine the heat of vaporization of water.

Materials Required:

Calorimeter can; steam boiler; 250-ml wide-mouth bottle with 2-hole stopper (or other water trap); thermometer; triple beam balance; tripod (or ring stand and ring); bunsen burner; striker; glass tubing; rubber tubing; apron; eyeshield; asbestos mitts; asbestos or cardboard shield.

Information:

(Refer to LAB--Heat of Fusion for discussion on internal energy changes).

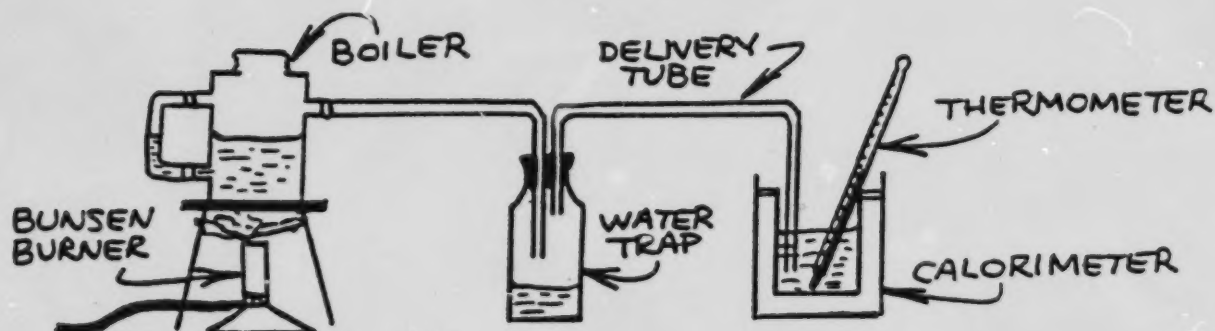
To change water at 100°C into steam, also at 100°C , requires heat. Note that, as with the heat of fusion, there is no resulting increase in temperature with the increase in heat. All the added heat is used to produce a change in phase or state--from a liquid to a gas.

The amount of heat necessary to change a substance at its boiling point from a liquid to a gas is called its HEAT OF VAPORIZATION or LATENT HEAT OF VAPORIZATION.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Set up the apparatus as indicated below. Do not start any heating operations until checked out by your instructor.
INSTRUCTOR'S INITIALS _____



Title: LAB--Heat of Vaporization

PAGE TWO

2. Start heating the water in the boiler (the boiler should be about half full of water). While waiting for the water to boil, weigh the calorimeter can. The mass of the calorimeter can is _____.
3. Fill the calorimeter can about two-thirds full of cold tap water. Weigh the calorimeter can and cold tap water. The mass is _____.
4. When steam is issuing freely from the delivery tube of the boiler, measure the temperature of the tap water in the calorimeter can (remember that this is the initial temperature of the calorimeter can as well as the water it contains). The initial temperature is _____.
5. Immediately immerse the delivery tube into the water so that its opening is near the bottom of the calorimeter can.
6. Stir the water constantly and gently with the thermometer. When the temperature has reached 35-40°C, remove the delivery tube (BE CAREFUL-- IT MAY BE HOT) from the calorimeter and turn off the bunsen burner. Stir the water thoroughly and record the temperature reached. The final temperature is _____.
7. Weigh the calorimeter can and its contents. The mass is _____.
8. The material of the calorimeter can is _____. Its specific heat is _____. The specific heat of water is _____.
9. Via the Law of Heat Exchange, the total heat lost is equal to the total heat gained. The total heat lost by the steam at 100°C as it condenses to water at 100°C and the resulting hot water (from the steam) as it cools from 100°C to its final temperature is equal to the total heat gained by the cold tap water in warming from its initial to final temperature and by the calorimeter can in warming from its initial to final temperature. Using the equation $\Delta H = m S \Delta T$, calculate the following (be certain to show all work in a neat, orderly fashion);

The heat gained by the cold tap water--

The heat gained by the calorimeter can--

The total heat gained--

Title: LAB--Heat of Vaporization

PAGE THREE

The heat lost by the water from the condensing steam--

10. Subtract the heat lost by the water from the condensing steam from the total heat gain. Then, divide this value by the number of grams of steam that were condensed. The result is the latent heat of vaporization and it is _____. Compare this value with the accepted value of the heat of vaporization of water. How much different were the two values? Explain why there may have been a difference--

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. What practical use do we make of the heat of vaporization of water? Explain.
2. Why is a burn caused by steam at 100°C more painful than one caused by water at 100°C ? Explain.

Title: LAB--Heat of Vaporization

INSTRUCTOR'S NOTES

Explain the use of the water trap (i.e., to keep the steam free of water.)

Remind the students to be certain that all of the delivered steam condenses in the water. This is why the delivery tube should be placed far enough below the water surface--for steam to condense completely before it rises to the surface.

The purpose of the cardboard or asbestos shield is to protect the calorimeter from the radiant heat of the boiler and the bunsen burner.

Be certain to remind the students that all references to weighing the calorimeter can refer to its inner cup.

Since it is assumed that the student already has performed the lab on Heat of Fusion, the procedure is not as guided (as far as directions for making necessary calculations) as that lab exercise.

COMMENTS:

Title: LAB—Law of Heat Exchange

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To test the Law of Heat Exchange.

Materials Required:

Bunsen burner; striker; tripod (or ring stand and ring); wire gauze;
water; calorimeter can; thermometer; 250-ml graduated cylinder;
100-ml. beaker; apron; eyeshield; asbestos mitts.

Information:

Whether you are taking a shower or a bath, or simply washing dishes, you find yourself mixing hot and cold water. You know that the resulting mixture, in any case, is warmer than the cold water but cooler than the hot water. You also know that heat energy will flow from a body that has more heat energy (or a high temperature) to one that has less heat energy (or a lower temperature). It follows, then, that heat energy must have flowed from the hot to the cold water. In fact, assuming that no heat energy is lost, according to the Law of Conservation of Energy the heat gained by the cold water is equal to the heat lost by the hot water. This is the Law of Heat Exchange.

To compute the heat lost or gained, simply multiply the mass of the water by its temperature change; or $\Delta H = m \Delta T$.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Set up bunsen burner and tripod (or ring stand and ring) for heating operation. Be certain to adjust bunsen burner so it burns with a clean flame.
2. Measure out 50 ml. of water and pour it into the beaker. Place on tripod and heat until it reaches about 80°C .
3. While water is heating, measure out 150 ml. of water and pour it into the calorimeter can. This will be the cold water. Determine the temperature as accurately as you can. The temperature of the cold water is _____ $^{\circ}\text{C}$.
4. Carefully remove the hot water from the burner and accurately determine its temperature. The temperature of the hot water is _____ $^{\circ}\text{C}$.

Title: LAB--Law of Heat Exchange

PAGE TWO

5. Immediately stir the mixture thoroughly and carefully with the thermometer until the thermometer reading no longer changes. The final temperature of the mixture is _____ °C.
INSTRUCTOR'S INITIALS _____.
6. Calculate the heat gained by the cold water. Multiply its mass (see Step 3) by its temperature change (the difference in temperature from Step 3 and 5). Show your calculations here:
7. Calculate the heat lost by the hot water. Multiply its mass (see Step 2) by its temperature change (the difference in temperature from steps 4 and 5). Show your calculations here:
8. Compare your results in the previous two steps. Are they the same? Does the heat gained by the cold water equal the heat lost by the hot water?

If there are any differences, how do you account for them?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Law of Heat Exchange

INSTRUCTOR'S NOTES

The heating operation may be eliminated if the lab is equipped with hot and cold tap water.

If time permits, this lab can be repeated with various temperatures of water or with various masses of water.

If calorimeter cans are not available, double styrofoam cups with a cardboard cover may be substituted.

COMMENTS:

//o.

Title: LAB--Specific Heat

Unit: Heat

Course: Physics

NOTE: SAFETY EQUIPMENT MUST BE WORN DURING THIS LAB.
ALL ACCIDENTS MUST BE REPORTED TO YOUR INSTRUCTOR.

Purpose:

To determine the specific heat of a metal.

Materials Required:

Metal specimen; bunsen burner; beaker; tripod (or ring stand and ring); wire gauze; thermometer; calorimeter; triple beam balance; string; apron; eyeshield; asbestos mitts; water.

Information:

The specific heat of any substance is the ratio of heat output of that substance to the heat output of an equal mass of water, the temperature changes being the same. If one compares aluminum and water, for example, it would be found that the aluminum releases about one-fifth as much heat as an equal mass of water undergoing the same temperature change. The number $1/4$ or 0.22 (to be more exact) is called the specific heat of aluminum. The water it is compared to has a specific heat of 1.

Looked at another way, the specific heat of a substance is the number of calories needed to raise the temperature of 1 gram of the substance 1 Celsius degree. In the case of aluminum, in our example, 1 gram of it can be raised in temperature 1 Celsius degree with only 0.22 calories of heat. Since it takes 1 calorie of heat to raise the temperature of 1 gram of water 1 Celsius degree, its specific heat is 1.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Set up apparatus for heating operations. Fill beaker about half full of water and bring to boiling.
2. While waiting for water to boil, weigh sample of metal. The mass of the metal is _____.
3. Attach string to metal sample and CAREFULLY lower sample into the boiling water. Leave the metal sample in the boiling water for at least five minutes.
4. While waiting for the metal to reach the same temperature as the boiling water, weigh your calorimeter can. The mass is _____. Half fill the calorimeter can with cold tap water, and determine the mass of the water. The mass is _____. Determine the temperature of the tap water. This is the initial temperature of the water and the calorimeter can. The initial temperature is _____.

Title: LAB--Specific Heat

PAGE TWO

5. Note the temperature of the boiling water. This is the initial temperature of the metal. The temperature is _____.
6. Very quickly, transfer the metal from the boiling water to the calorimeter and stir the water thoroughly with the thermometer. Watch the thermometer and note the highest temperature to which the water rises. This is the final temperature for the water, the metal sample, and the calorimeter. The final temperature is _____.
7. Using the Law of Heat Exchange--that heat gained equals heat lost--list the substance(s) that gained heat and the substance(s) that lost heat. Write the necessary equations and make the necessary substitutions from the data secured in this lab. Look up the appropriate specific heat for the material your calorimeter is made of (of course, you already know that the specific heat of water is 1). Solve for the specific heat of the metal specimen. Show all your work below in a neat, orderly fashion:

8. When your calculations are complete, look up the accepted value for the metal specimen. It is _____. How does it compare to your calculated value?

Can you account for any errors in this lab that may have made the values different?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB-- Specific Heat

PAGE THREE

Trade Relatedness:

1. Why is water used in the cooling system of an automobile? Explain.

SPECIFIC HEAT

Aluminum	0.21
Brass	0.09
Copper	0.09
Glass, crown	0.16
Ice	0.50
Iron, cast	0.12
Lead	0.03
Mercury	0.03
Platinum	0.03
Silver	0.06
Steam	0.48
Water	1.00
Zinc	0.09

Title: LAB--Specific Heat

INSTRUCTOR'S NOTES

Be certain to remind the students that all references to weighing the calorimeter refer to its inner cup.

A variation of this lab may be attempted. Have the student heat three or four metal specimens at the same time in boiling water (each sample is attached by string to a rod). After five minutes or so, have the students remove the samples and immediately rest on a block of paraffin wax. The penetration into the wax can be determined. The metal with the higher specific heat has the greatest penetration, etc. Be certain that all of the samples have the same mass when attempting this variation.

COMMENTS:

Title: LAB--Dew Point Temperature

Unit: Heat

Course: Physics

Purpose:

To determine the dew point temperature of the atmosphere.

Materials Required:

Shiny metal can (tin can or calorimeter can insert); beaker; thermometer; water; ice chips.

Information:

Cold air is dense and therefore cannot hold a great deal of water vapor. Conversely, warm air being less dense, can hold much more water vapor. If warm air, carrying a specific amount of water vapor, were to gradually become cooler, its water vapor-holding ability would begin to decrease as the temperature decreased. Soon a point would be reached when the air is saturated (or filled to capacity with water vapor). If the air were to be still further cooled, it could no longer hold the water vapor and the excess would take the form of condensation (liquid water droplets).

You have, undoubtedly, observed this happening many times. After a hot summer day, followed by a cool night, you go outside and find that the lawn is wet or that the windshield on the car is wet (these droplets of water are called dew). Or, after you have taken a bath or shower, you notice that the mirror is "fogged".

The temperature to which the air must be cooled in order to have saturation occur (or to have condensation take place) is called the DEW POINT TEMPERATURE or the DEW POINT.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Pour some tap water into the metal can to a depth of about 2.5 cm. (1 in.). Carefully place the thermometer in the can. Note the temperature.
2. Slowly add chips of ice while stirring constantly with the thermometer, DO NOT TOUCH THE CAN OR BREATHE ON IT.
3. Watch the shiny surface of the can continuously and note the temperature at which dew begins to form on the surface of the can (the shiny surface will begin to dull). The temperature at which dew began to form was _____.
4. Remove any remaining ice from the can. Add small amounts of tap water (warm) to the can and stir constantly with the thermometer.

Title: LAB--Dew Point Temperature

PAGE TWO

5. Continue to add warm water slowly and record the temperature at which the dew disappears. The temperature at which dew disappeared was _____.
6. Average the two temperatures (see Steps 3 and 4). This average is the dew point temperature. The dew point is _____.
7. If your instructor so directs, repeat the procedure for two more trials and calculate the average of the dew points. Average _____.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT EVERYTHING IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. What is a vapor barrier? Why is it used? Give some examples of its use in the construction area.
2. When dew forms on the inside of an automobile windshield, how is it eliminated? Explain.
3. What causes water pipes in a house to "sweat"? Explain.
4. Air conditioners are used to cool the air in a room. Many times they also effect the moisture content of the room. Explain how this might be possible.

Title: LAB--Relative Humidity

Unit: Heat

Course: Physics

Purpose:

To determine the relative humidity of the atmosphere.

Materials Required:

2 thermometers; small beaker; cotton wick or cloth; cardboard (or other item for fan); ring stand; rod; rod clamp; water.

Information:

Relative humidity is related to dew point temperature. It is defined as the ratio of the amount of water vapor actually in the air to the maximum amount the air can hold at that temperature. Since the water vapor actually in the air is often called specific humidity and the maximum amount the air can hold is called capacity, relative humidity is also defined as the ratio of the specific humidity to capacity. It is expressed as a per cent.

The analogy often used is that of a quart container with various amounts of water. If the container was half full of water, its capacity was not reached and it could hold more. It could be likened to a relative humidity of 50%. However, if the container were filled to the top, it would be at capacity and, if more was put in, it would spill over. It is like 100% relative humidity. The "spill-over" would be similar to condensation occurring in our atmosphere or dew forming on objects.

A low relative humidity indicates dry air so, obviously, a high relative humidity indicates moist (or humid) air. It follows that relative humidity is also related to evaporation. If the air is dry, more evaporation can take place; and when humid, little evaporation can take place.

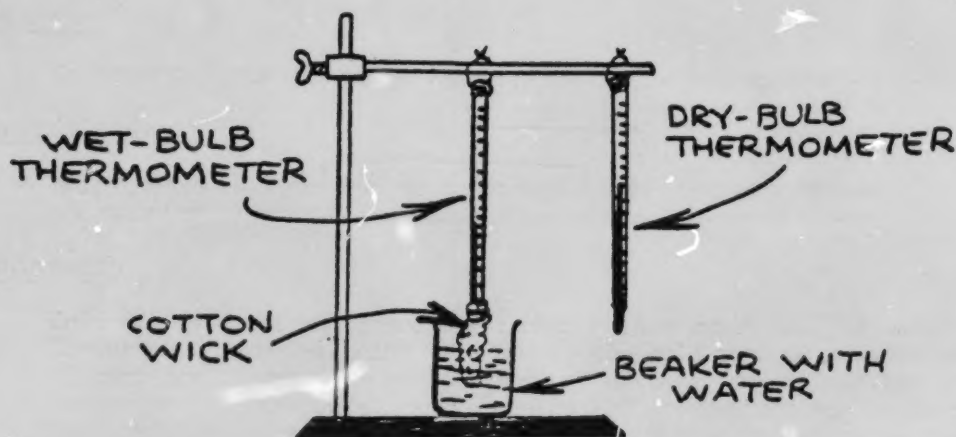
A device for measuring relative humidity is called a hygrometer. One which uses a wet-and dry-bulb thermometer is often called a psychrometer. The psychrometer's dry-bulb thermometer gives the normal air temperature reading. The wet-bulb thermometer takes advantage of the fact that evaporation is a cooling process. If the air is very dry, more evaporation can take place and the lower the temperature reading. On the other hand, if the air is already fairly humid less evaporation will take place and the temperature will drop very little.

Procedure:

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Get two thermometers from your instructor. Carefully wrap the cotton cloth or wick around the bulb of one of the thermometers. Let some excess hang down. This will be the wet-bulb thermometer. Do not attach anything to the bulb of the other thermometer. This will be the dry-bulb thermometer.

2. Set up the apparatus as shown in the following diagram:



3. Fill the small beaker about two-thirds with water. For best results the water should be room temperature.
4. Immerse the wick or cloth of the wet-bulb thermometer in the beaker. Do not submerge the bulb of the thermometer in the water.
5. Fan the bulbs of both thermometers with the piece of cardboard. Be careful not to bang the thermometers. Continue this fanning process until the wet-bulb temperature stops falling and remains constant.
6. The dry-bulb temperature reading is _____.
The wet-bulb temperature reading is _____.
The difference between the two readings is _____.
7. Using the data from the previous step, determine the relative humidity from the table on the following page. The relative humidity is _____.
8. If your instructor so directs, repeat the procedure for two more trials and calculate the average of the relative humidities.
Average _____.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT EVERYTHING IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Trade Relatedness:

1. What is the difference between a humidifier and a de-humidifier? Explain. Under what conditions would each be used?

2. Why are you sometimes told that rather than turning up the thermostat on your home heating system, you should increase the humidity? Explain.
3. What effect does humidity have on furniture and other wood products in the home? Explain.
4. In many printing operations and computer operations, the relative humidity must be carefully controlled. Why? Explain.
5. What effect does humidity have on comfort? Explain.
6. What effect does humidity have on hair? Explain.

RELATIVE HUMIDITY (Figures in intersection of columns give relative humidity in per cents)

Reading of Dry-Bulb Thermometer (°F)	Difference between Readings of Wet- and Dry-Bulb Thermometer (°F)															
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°
60°	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21
61°	94	89	84	78	73	68	63	58	54	49	44	40	35	31	27	22
62°	94	89	84	79	74	69	64	59	54	50	45	41	36	32	28	24
63°	95	89	84	79	74	69	64	60	55	50	46	42	37	33	29	25
64°	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26
65°	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27
66°	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29
67°	95	90	85	80	75	71	66	62	58	53	49	45	41	37	33	30
68°	95	90	85	80	76	72	67	62	58	54	50	46	42	38	34	31
69°	95	90	85	81	77	72	67	63	59	55	51	47	43	39	35	32
70°	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33
71°	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33
72°	95	90	86	82	78	73	69	65	61	57	53	49	45	42	38	34
73°	95	91	86	82	78	74	69	65	61	57	53	50	46	42	39	35
74°	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36
75°	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37
76°	96	91	87	82	79	74	70	66	62	59	55	51	48	44	41	38
77°	96	91	87	83	79	75	71	67	63	59	56	52	48	45	42	39
78°	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39
79°	96	91	87	83	79	75	71	68	64	60	57	53	50	46	43	40
80°	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41
82°	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42
84°	96	92	88	84	80	76	73	69	66	62	59	56	52	49	46	43
86°	96	92	88	84	81	77	73	70	66	63	60	57	53	50	47	44
88°	96	92	88	85	81	77	74	70	67	64	61	57	54	51	48	46
90°	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47

Title: LAB--The Rubber-Band Wheel

Unit: Heat

Course: Physics

Purpose:

To observe the rubber-band wheel and determine its operation.

Materials Required:

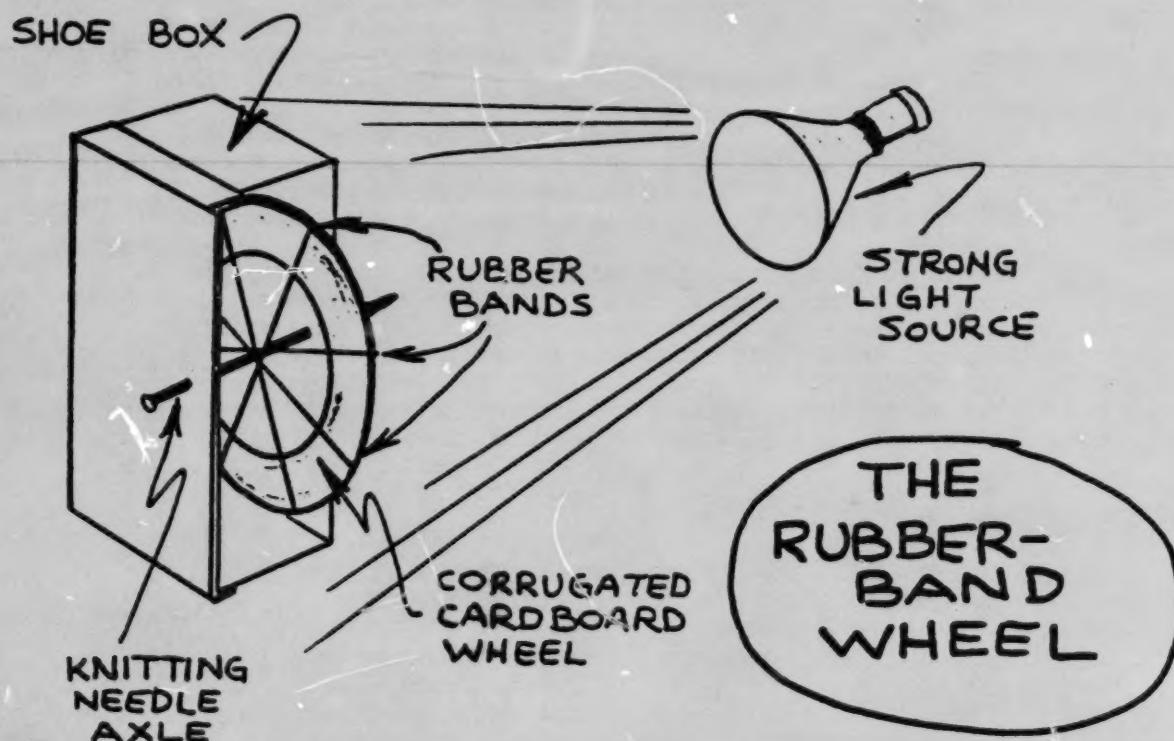
Shoe box; 6 in. diameter cardboard wheel; knitting needle (or other similar axle); 4 fresh rubber bands (of equal length and thickness); strong light source (such as 150-watt spotlight).

Information:

There will be no information given. Your instructor will have the necessary apparatus set up. You will observe the action of the apparatus and attempt to arrive at the necessary conclusions.

Procedure:

1. Observe the apparatus diagrammed below:



Title: LAB--The Rubber-Band Wheel

PAGE TWO

2. Ask yourself some questions. What do you observe? What are the parts? What is the action? What is the setup? What are some possible explanations?
3. What further experimentation would you recommend to test your possible explanations? Ask yourself--"what would happen if?"
4. What is your explanation? What are the facts? What are the conclusions?

Title: LAB--The Rubber-Band Wheel

INSTRUCTOR'S NOTES

It is recommended that this lab exercise be performed as a demonstration with student assistance so that the instructor may better control the analyzation process. However, this lab can be performed by the students themselves if desired.

When the students get to Step 2, you may recommend that they suspend a weight on a single rubber band fastened to a support and exposed to the light. This may give them some clues.

In this lab, an exception to a scientific generalization is made. In general, solids expand when heated and contract when cooled. Rubber bands in tension are an exception--they contract when heated and expand when cooled. In the case of this lab, they pull the center of rotation to one side (making one side of the wheel heavier than the other) and cause turning to take place.

COMMENTS:

Title: LAB--Solar Water Heater

Unit: Heat

Course: Physics

Purpose:

To construct a simple solar water heater and test its operation.

Materials Required:

Hot water baseboard heating element (firmed radiator tubing) about 4 ft. long; wooden support box (plywood or other) $1\frac{1}{2}$ ft. by $1\frac{1}{2}$ ft. by length to match heating element; clear plastic or glass cover for support box; 2 copper pipe caps; 4 2-in. sections of $1/4$ in. copper tubing; gallon can (such as spirit master fluid can); rubber or plastic tubing of size and length as necessary; 4 mini hose clamps; aluminum foil; cardboard; flat black paint; water or anti-freeze solution; necessary tools and supplies for assembly (e.g., glue; nails; solder; drill; stapler; etc.)

Information:

The depletion of fossil fuels, rising costs, and other factors have led people to seek out alternate sources of energy. One type is solar energy. Here, for example, the heat energy from the sun can be captured and utilized. This energy can be then used to heat our homes, pre-heat our hot water, and so on.

Very basically, solar heating systems consist of four parts: collection, transportation, storage, and circulation. Collection requires the use of some device, such as a solar panel, which takes the heat energy from the sun. The transportation part requires the use of materials, such as pipes or ducts which may be filled with fluids such as air or water, to transfer the heat from the collector to storage or area of use. The storage is used primarily to store heat to compensate for times when collection is impossible or minimal (for example, at night or on cloudy days). The final part, circulation, requires some means (such as pumps or gravity) to get heat back into the system once it has been used up.

This lab will deal with the construction and use of a very simple solar water heater.

Procedure:

NOTE: DUE TO THE NATURE OF THIS LAB, YOUR INSTRUCTOR MAY CHOOSE TO HAVE THIS EXERCISE PERFORMED AS AN ENTIRE CLASS PROJECT, A SMALL GROUP PROJECT, OR AN INDIVIDUAL PROJECT. DIAGRAM ON PAGE THREE.

FOLLOW ALL DIRECTIONS STEP-BY-STEP. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Cut wood for the support box. The overall dimensions of the box will be $1\frac{1}{2}$ ft. x $1\frac{1}{2}$ ft. x length to accommodate the heating element.

2. Drill holes in each end piece of the box to accommodate the tubing of the heating element. The holes should be drilled at the focus of the parabola made by the reflective material.
3. Paint the tubing and fins of the heating element with flat black paint. Use caution since the fins are sharp.
4. Assemble the support box, leaving one end off to allow insertion of heating element.
5. Fit a piece of cardboard the length of the box and bend it so it makes a parabolic shape. Cut as necessary.
6. Attach aluminum foil to the cardboard. Be certain it is smooth. This is the reflective material. Fit the reflective material in the box and staple it in place.
7. Insert the heating element in place and attach the remaining end of the box. Paint the outside of the box with exterior paint if desired.
8. Fit a plastic or glass cover on the box and attach.
9. Drill holes in each of two pipe caps to fit the 1/4-inch copper tubing. Solder one piece of tubing to each cap, then solder the entire assembly to each end of the heating element.
10. Drill two holes in the gallon can to fit the 1/4-inch copper tubing. Drill one hole near the top of the narrow side of the can and drill the other hole near the bottom of the opposite narrow side. Solder one piece of tubing to each hole.
11. Cut rubber or plastic tubing to the length prescribed by your instructor and attach to the 1/4-inch copper tubing by means of the mini hose clamps.
12. Fill entire unit with water or the anti-freeze solution. Check for leaks.
13. Place unit as directed by your instructor. Be certain that the storage can is set higher than the collector. Also be certain to raise the end of the collector that is attached to the top of the storage can (to permit circulation without the use of a pump).
14. Collect the required data indicated by your instructor.

CLEAN UP YOUR WORK STATION. PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR.
INSTRUCTOR'S INITIALS _____

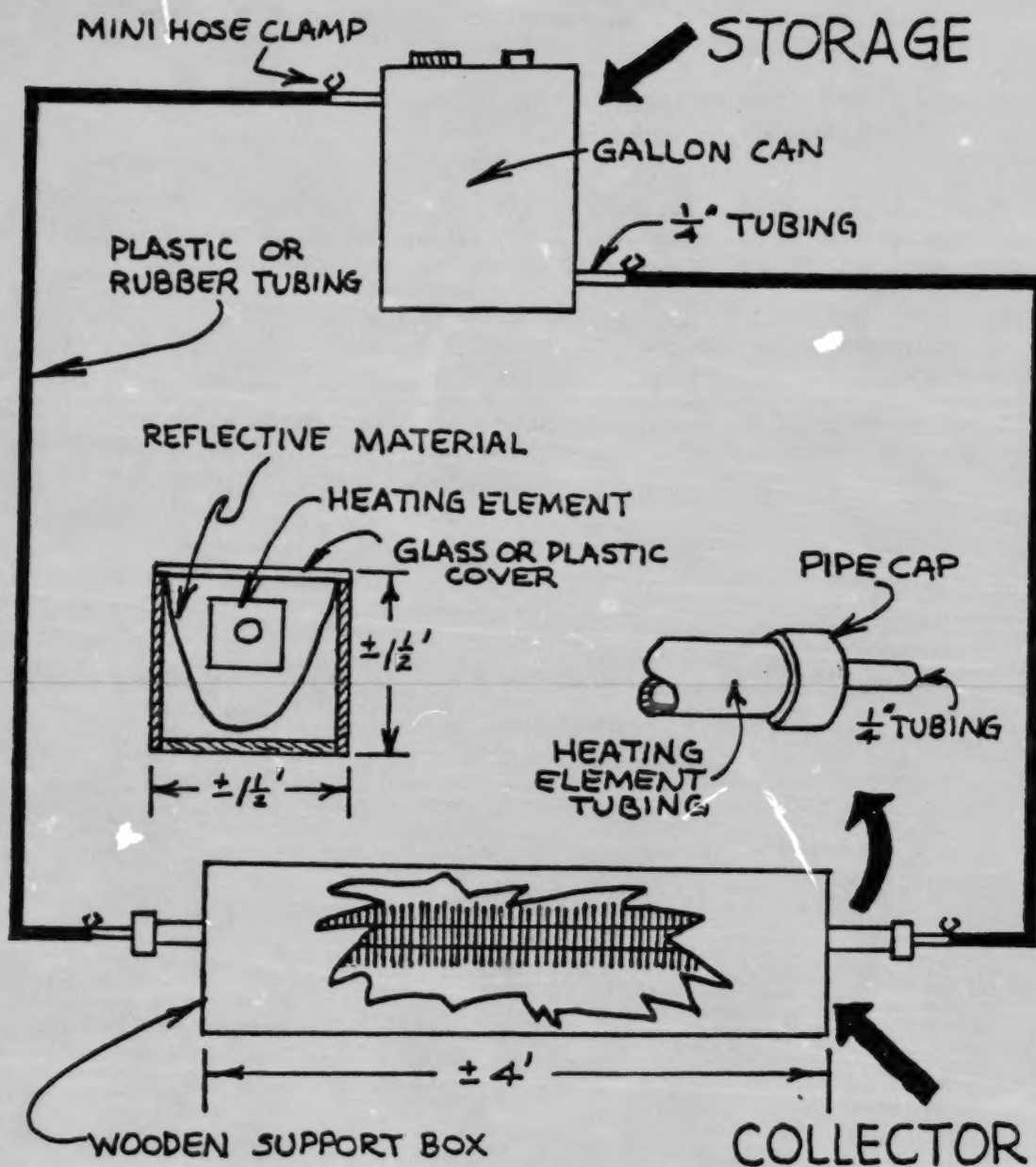


DIAGRAM OF SIMPLE
SOLAR WATER HEATER

Title: LAB--Solar Water Heater

INSTRUCTOR'S NOTES

This lab exercise may be used as a project for an individual, a small group or an entire class.

If desired, portions of the heater may be made in advance in some of the shops. Final assembly can be done in the lab.

Placement of the heater is up to the instructor. The entire assembly may be placed in the sun, or just the collector be placed in the sun with the storage can inside the lab.

Thermometers can be installed, if desired, to monitor the temperatures at different points in the assembly. For example, one might be installed inside the collector, one outside, and one in the storage can.

Variations can include the testing of various materials for a cover, various reflective materials (and various shapes), different paints for the heating element, etc.

With this initial project, the students may design and develop other solar projects and may even include a bona-fide working solar heating system.

COMMENTS:

MISCELLANEOUS

130
127.

Title: LAB--Color Blindness, Deafness, Blindness

Unit: Light and Sound/Miscellaneous

Course: Physics

Purpose:

To witness the effects of color blindness, deafness, and blindness.

Materials Required:

Slide projector (or film strip projector with slide projection apparatus); Wescott Color Slides Set (for testing color blindness); projection screen; 3 x 5 index cards (or paper of similar size); clock or other timing device; eye patches and cloth for blindfolds.

Information:

FOR THE INSTRUCTOR:

The format for this lab is different from other labs in this Project Book. It is presented for the instructor, rather than for the student as in previous labs.

The purpose of this lab is to actually get the students to witness some handicaps such as color blindness, deafness, and blindness. At the conclusion of this lab, the students are to respond either verbally (via a group discussion) or on paper (via a brief report) to express their feelings in regard to this lab.

Part 1.--Conduct a color blindness test using the Wescott Color Slides Set. Have the students take the test. Discuss the problems of color blindness (bring in trade areas or areas in life where it may be a critical problem). Discuss the degrees of color blindness and methods of checking for it. Show the students, via the Set, what the "world of color" looks like to a color blind person.

Part 2--Prepare a series of statements on 3 x 5 index cards (or paper of similar size). The statements should be conversational or communicative in nature--for example, "Stop by the gas station to get some gas"; "School is not closed. It will open an hour late"; "Go to the store and get a loaf of bread"; etc. The length and complexity of the statements are left to the discretion of the instructor. Using this as a guide, distribute the cards to pairs of students and have one communicate the contents of the card in a prescribed time limit. Switch cards and/or switch partners to insure that everyone has had an opportunity to act as sender and receiver more than once. The catch to this exercise is that the contents of the cards cannot be communicated by speaking--other methods have to be found and tried. Accuracy of communication should be discussed. Methods of communicating should also be discussed.

Title: LAB--Color Blindness, Deafness, Blindness

PAGE TWO

Part 3--Pair off the students. Have one student in the group cover the eyes and wrap a cloth over them for a blindfold. The other student will act as a guide. Have the groups of students circulate around the school building or around the campus to feel the full effect of negotiating without sight. Each student should keep on the blindfold for at least fifteen minutes or longer and then switch roles with the student that had acted as the guide. After a prescribed time has elapsed, have all students return to the class or lab. Discuss the experiences of the students. Discuss the problems encountered. Discuss the frustrations.

SOUND

133

130.

Title: LAB--Wave Properties

Unit: Light and Sound

Course: Physics

Purpose:

To observe wave characteristics.

Materials Required:

Coil springs (a "Slinky" of about 8 to 10 m diameter and a heavy metal coil of about 2 to 3 cm diameter), thread or light string, meter stick or metric tape, stop watch or other timing device.

Information:

There are wave characteristics that are common to all waves whether they be light, sound, or even water waves. In general, all waves follow the same rules. Since this is true, you will experiment with waves in coiled springs in order to learn about waves in general.

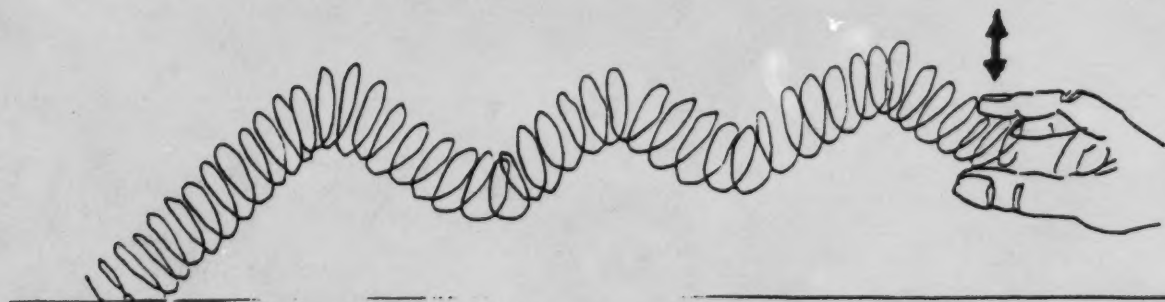
Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

CAUTION: You will be using stretched springs in this lab. Avoid releasing an end of the spring as tangles may result.

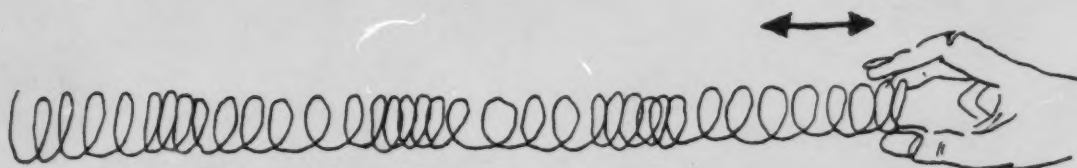
1. TRANSVERSE AND LONGITUDINAL WAVES

Place slinky on a smooth surface and stretch it out to a length of 8 to 10 m (Determine the best stretch distance for the coil by experiment and be careful not to exceed the stretch limit of the coil). Practice shaking one end of the slinky sideways until a clear pulse is sent along its length.



Several pulses together will form a transverse wave train. Note the direction in which the pulses travel and the direction in which the slinky coils move. In a transverse wave, which way do the particles of the medium (slinky) vibrate with respect to the direction in which the wave is travelling?

Reach a short distance down the slinky. Gather the coils toward you and quickly release them.



The pulse that travels along the slinky is a longitudinal wave. In a longitudinal wave, which way do the particles of the medium (slinky) vibrate with respect to the direction in which the wave is travelling?

2. SPEED OF WAVES

Keep the stretch on the slinky constant. Generate a transverse wave. Estimate the speed of the wave in the slinky or time the pulse with a stopwatch. Generate a second wave, making it larger or smaller than the first one. Compare the speeds. Repeat, if time permits, for waves of varying sizes. What generalization can you make concerning the speed of all waves in a particular medium?

3. WAVELENGTH AND FREQUENCY

Generate wave trains in the slinky by rapidly shaking it back and forth. The wavelength of the wave in the slinky is the distance from one crest to the next (on the same side). The frequency of a wave is the same as the frequency at which the slinky is shook. Shake the slinky regularly but slowly, then regularly but rapidly. Observe the wavelengths of the waves. What kind of wavelength does a high frequency wave have?

PAGE THREE

What kind of wavelength does a low frequency wave have?

4. INTERFERENCE OF WAVES

Send pulses from each end of the slinky at the same time. Observe the pulses when they come together and after they pass through each other. Try pulses of the same and of different shapes. Send a pulse down one side of the slinky while another is sent down the opposite side. Observe what happens when they meet. When two waves meet in this slinky, what happens to their displacement (size)?

What happens when two waves of equal size meet, after approaching each other from different sides of the slinky?

What happens to waves after they pass through each other?

5. REFLECTED WAVES

Hold one end of the slinky very rigidly, then send a pulse to the rigid end. Observe the reflected pulse. What happens to the wave when its reflected from a rigid medium?

Tie a thread or thin string to one end of the slinky. Hold the slinky via this string or thread. Send a pulse to the end supported by the string. Observe the reflected wave. What happens to the wave when its reflected from a medium less rigid than the one it's been travelling in?

6. WAVE TRANSFERRAL

Connect one end of the slinky to one end of the other coil spring. Stretch the assembly out as before and hold down the loose end of the slinky and that of the other coil. Send pulses down each spring. Observe what occurs at the boundary between the two springs. Observe the change in the wave as it passes from one spring into another. What happens each time a wave reaches the boundary between the two springs?

What happens to the speed of a wave as it enters a new medium?

What happens to the wavelength of a wave as it enters a new medium?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Wave Properties

INSTRUCTOR'S NOTES

Due to the space involved, this exercise may have to be performed in a hallway or corridor.

Since there are several assignments to do in this exercise, lab groups of four or more students are practical.

COMMENTS:

Course: Physics

Purpose:

To determine the best resonant length of a closed tube for sounds of known frequency and to determine the speed of sound from the wavelengths and frequencies of several sounds.

Materials Required:

Tuning forks of known frequency, rubber striker, tall cylinder (such as 1000 ml graduated cylinder), meter stick, Celsius thermometer, glass tube (2.5 to 4 cm diameter and about 40 cm long).

Information:

Resonance, or sympathetic vibration, occurs when the natural vibration rates of two objects are the same. The air column in a closed glass tube produces its best resonance when its approximately one-fourth as long as the wavelength of the sound which it reinforces. A small correction in wavelength must be made for the internal diameter of the tube. The wavelength of the sound may be calculated from the resonant length of the tube by the equation $L = \frac{\lambda}{4} (1 + 0.4d)$, where "L" is the wavelength, " λ " is the length of the closed tube, and "d" is the diameter of the tube.

The speed of sound will be calculated from the equation $v = fL$, where "v" is the speed of sound, "f" is the frequency, and "L" is the wavelength. This experimental value will be compared to the accepted speed of sound. The latter will be calculated by using the equation $v = 332 + 0.6T$, where "v" is the speed of sound and "T" is the temperature.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

CAUTION: Quiet must be maintained during this lab (i.e., talking cannot be permitted) while the best resonant length of the tube is being found.

1. Fill the tall cylinder with water to about 2.5 cm from the top.
2. Carefully lower the glass tube into the cylinder all the way to the bottom.
3. Make the tuning fork vibrate by striking with the rubber hammer. DO NOT STRIKE TUNING FORK ON LAB BENCH OR OTHER HARD SURFACE.

Title: LAB--Resonance and Velocity of Sound

PAGE TWO

4. Hold tuning fork about 2.5 cm above glass tube and slowly raise the glass tube. KEEP FORK ABOVE GLASS TUBE. Note the position where resonance produces the loudest sound by slowly moving the glass tube up and down.
5. When the loudest sound is noted, hold the glass tube firmly and measure the length of the tube from its top to the water surface inside the tube. Record the length in the table to the nearest thousandth of a meter.
6. Carefully measure the inside diameter of the glass tube. Record the diameter in the table to the nearest thousandth of a meter.
7. Determine the temperature of the air inside the tube, using the thermometer and record it in the table.
8. Record the frequency of the tuning fork in the table. It should be stamped on the fork.
9. Calculate the wavelength and speeds of sound using the equations identified in the "Information" portion of this lab.
10. Determine the relative error.
11. Repeat for at least two other trials, each time using a tuning fork of different frequency.

	TRIAL 1	TRIAL 2	TRIAL 3
LENGTH OF TUBE	m	m	m
DIAMETER OF TUBE	m	m	m
CALCULATED WAVELENGTH	m	m	m
FREQUENCY	hz	hz	hz
TEMPERATURE	°C	°C	°C
EXPERIMENTAL SPEED OF SOUND	m/sec	m/sec	m/sec
ACCEPTED SPEED OF SOUND	m/sec	m/sec	m/sec
RELATIVE ERROR	%	%	%

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Resonance and Velocity of Sound

INSTRUCTOR'S NOTES

If a tuning fork hammer is not available, a rubber stopper (with one hole) mounted on a dowel can be used.

COMMENTS:

TITLE:

Lab-Musical Sounds

UNIT:

Sound

COURSE:

Physics

PURPOSE:

1. To show the difference between noise and a musical note.
2. To show that the pitch of a note depends upon the number of vibrations per second.

MATERIALS REQUIRED:

Rotating siren disc.
Air nozzle connected to a compressed air unit.

PROCEDURE:

1. With the siren disc revolving at a moderate speed, direct air from the nozzle to the outside row of equidistant holes. Note the sound which is made. With the nozzle held in the same place, speed up the disc and note any difference in the sound.
2. With the disc rotating, direct the nozzle to the row of unequal spaced holes; note the sound.
3. With the air nozzle directed at the disc, vary the speed of the disc and note any change in the sound. Also change from one row of holes to the other and note any change.

CONCLUSION:

1. Which row of holes produced a musical note?
2. What effect did increasing the speed of the disc have upon the pitch of a note?
3. For a given speed, compare the pitch of the note produced by the outer row of equally spaced holes with another row of equally spaced holes but only have in number.
4. What difference, if any, is there in the sound produced by a row of equally spaced holes and the row of unequally spaced holes?

Title: LAB--The Bell Jar

Unit: Sound

Course: Physics

Purpose:

To determine whether sound waves travel through material or through a vacuum.

Materials Required:

Electric Bell, Battery, Switch and #20 copper wire, Vacuum Pump, Plate and a bell jar, Rubber pad, rubber band and scotch tape.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP YOUR STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Place a rubber pad on a bell jar plate and hang an electric bell by a rubber band within the bell jar.
2. Connect the bell with a switch and a battery by running wires through the rubber band.
3. Attach vacuum pump to the bell jar plate and start to exhaust the air.
4. Close the switch for a short period of time and repeat frequently as the air is being exhausted. Note any change in the sound of the bell.
5. Stop the pump and allow the air to reenter the bell jar with the switch still closed, noting any change in the sound.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. When did the bell sound the loudest and when the faintest?
2. Did the sound travel better through the air or through the vacuum?
3. How would sound travel through a perfect vacuum?

Title: LAB--Sound Insulation

Unit: Sound

Course: Physics

Purpose:

To note the difference in sound transmission through different types of panels.

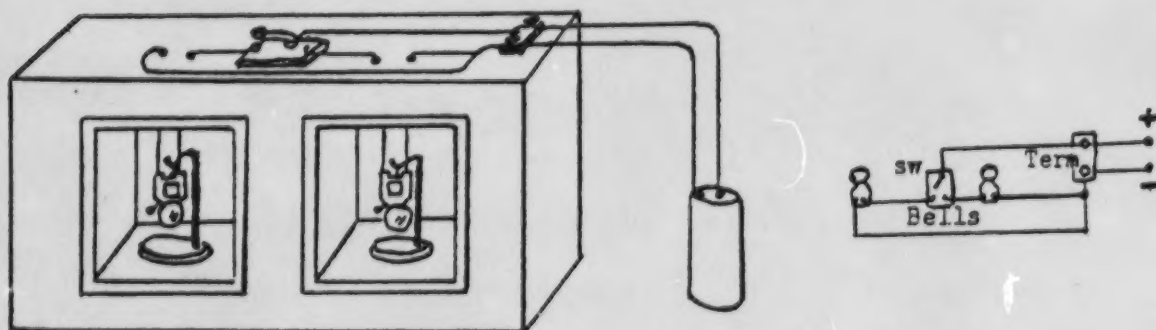
Materials Required:

Double opening sound box, Two electric bells, terminal, Battery and wire, Double throw switch, 14" panels, Single sheets of sheet metal, paper, cloth, heavy felt, 1/8", 3/8" and 3/4" plywood, 1" cork, Double surface panels of some of the above materials nailed through rigid spacers; Double surface panels of some of the above materials with surfaces insulated from each other; Double surface panels of 1/4" plywood insulated from each other and filled with sawdust, rockwool, cotton waste.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Connect the electric bells as indicated and test for matched sound with both openings open. Do this by switching from one bell to the other to detect any difference in sound. Note: Do not proceed with this experiment until satisfied that the apparatus is satisfactory in that both bells sound alike and with equal volume.



Title: LAB--Sound Insulation

PAGE TWO

Procedure: (Continued)

2. Place a panel over one opening and compare the sound coming through panel with sound from other opening.
3. Repeat using all panels - make a data table like the one on the following page listing the panels in order of sound transmission - that is, place those that pass the most sound first and those that pass the least sound last.
4. Whenever you have difficulty in distinguishing between two panels, place the two side by side in the two openings to determine which one transmits the most sound.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. Which panel transmitted sound the best?
2. Which panel provided the best insulation against sound passage?
3. Make a statement of your conclusions regarding sound insulation.

Title: LAB--Sound Absorption

Unit: Sound

Course: Physics

Purpose:

To note the difference in sound absorption of different kinds of material.

Materials Required:

Double opening sound box complete with bells, batteries and connections (refer to LAB--Sound Insulation), opening liners of different materials (metal, plywood, plaster board, Homosote, Celotex, acoustical Celotex, linoleum or floor tile, heavy cloth, acoustical plaster, etc.)

Information:

Some materials do not carry sound well while others carry sound very well. Rooms that have hard floors, walls and ceilings often seem very noisy since sounds bounce off these hard materials. To reduce the noise, materials which soak up the sound waves are used. Heavy curtains and drapes help cut down on noise. Acoustical ceiling tile also makes a room less noisy. The use of special materials to make a room quiet is called SOUNDPROOFING.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Connect the electric bells and test for matched sound with both openings open and bare. Do not proceed until satisfied that both bells are alike in tone and volume.
2. Place a liner in one opening so that the five surfaces are completely covered and compare the sound coming from that opening with the sound coming from the other opening which is bare.
3. Repeat using all the different liners. Make a data table listing the materials of the liners in order of sound absorption--that is, place the material first where you hear the least sound and last where you hear the most sound.
4. Whenever you have difficulty in distinguishing between two materials, place one material in one opening and the other material in the other to determine which material absorbs the most sound.

Title: LAB--Sound Absorption

PAGE TWO

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS
PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. Which material absorbed the most sound?
2. Which material reflected the most sound?
3. What common characteristic, if any, did you notice among
good sound absorbing materials?
4. Make a statement of any conclusions that you may have
reached regarding the sound reflecting or absorbing
qualities of different materials?

LIGHT

Title: LAB--Index of Refraction of Glass

Unit: Light

Course: Physics

Purpose:

To determine the index of refraction of a sample of glass.

Materials Required:

Refraction block (rectangular glass plate), metric ruler, drawing compass, unruled paper, sharp pencil, straight pins, cardboard.

Information:

Objects on the bottom of a tank of water appear to be nearer to the surface than they actually are. A pole sticking obliquely from the water appears to be broken at the surface.

This bending of light as it passes from one substance to another is called refraction. Refraction occurs because light travels at different velocities in different materials. The ratio of its velocity in air to its velocity in another substance is called the index of refraction of that substance.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

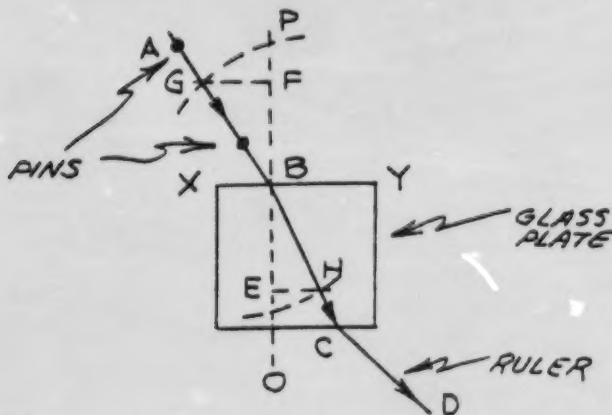
1. Draw a line on a piece of paper. Place the glass plate over the line.
2. Look at the line perpendicularly from above. Draw a simple sketch to show how the line appears.
3. Move your head so that the line is viewed through the glass in a slanting direction. Again draw a simple sketch to show how the line appears.

What differences were there in the appearance of the line?

Title:

PAGE TWO

4. Place the cardboard on the lab bench (this will provide a base into which you will place some straight pins). Place a sheet of unlined paper on the cardboard.
5. Place the glass plate on the paper and draw a sharp pencil line around it.
6. Place two straight pins back of the glass being certain that they are not in a line perpendicular to the edge of the glass (Refer to diagram below).



7. Lay the ruler on the bench in front of the glass plate. Sight along the edge of the ruler and place the edge of the ruler directly in line with the two pins AS SEEN THROUGH THE GLASS.
8. Draw a pencil line along the edge of the ruler (the edge sighted along). Remove the glass plate and extend this line until it meets the line indicating the edge of the glass nearest you. Label this intersection C.
9. Draw the lines AB and BC. At B, erect the normal (perpendicular) to XY. Mark with arrows on AB, BC, and CD the direction of the light.
10. On AB and BC strike off equal arcs (G and H). From these points, drop FG and EH perpendicular to OP (You have completed two right triangles with equal hypotenuses).
11. Label the angle of incidence "i" on your diagram. Label the angle of refraction "r" on your diagram.

Title: LAB--Index of Refraction of Glass

PAGE THREE

12. The index of refraction of the glass may be found from the ratio of the sine of the angle of incidence to the sine of the angle of refraction. On the drawing, the sine of the angle of incidence is FG/BG and the sine of the angle of refraction is EH/BH . Therefore, the index of refraction is $FG/BG \div EH/BH$. Since BG and BH represent equal hypotenuses, the index of refraction simply becomes the ratio of FG/EH .
13. Carefully measure FG and EH to tenths of a millimeter. Calculate the index of refraction of the glass you used.

Length of FG _____ mm

Length of EH _____ mm

Index of Refraction of Glass _____

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Images Produced by a Plane Mirror

Unit: Light

Course: Physics

Purpose:

To determine the image produced by a plane mirror.

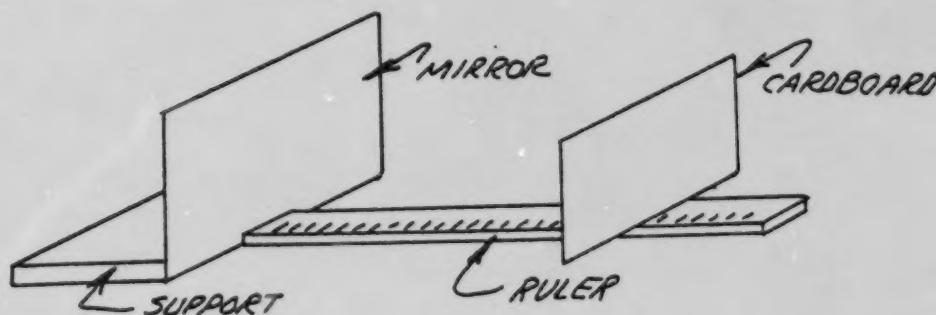
Materials Required:

Plane mirror 6" x 6", Cardboard 2" x 4", 12" ruler

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP YOUR WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Support the mirror in vertical position as shown.



2. Print your name across the center of the cardboard.
3. Place the ruler in front of the mirror and normal to it.
4. Place the cardboard with your name facing and parallel to the mirror: (a) 4" from the mirror (b) 6" from the mirror (c) 8" from the mirror. Observe images formed.
5. Remove ruler and keeping the cardboard vertical, move the right side of the cardboard closer to the mirror than the left. Observe image.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Images Produced by a Plane Mirror

PAGE TWO

Conclusions:

1. How did the name appear in the mirror?
2. How did the size of the cardboard in the mirror compare with the original?
3. In step #4, how far did the cardboard appear behind in (a), (b), (c)?
4. How did this distance compare with the actual distance?
5. When you moved the right side of the cardboard closer to the mirror which side of the cardboard image moved closer?
6. Was the image produced in each instances real or virtual, inverted or erect, smaller, magnified, or identical in size?

Title: LAB--The Headlight Lamp

Unit: Light

Course: Physics

Purpose:

1. To show how light reflects in a parabola.
2. To show how light reflects at high and low positions on a road.
3. To show how the lens affects the beam of light.

Materials Required:

Wood 7" x 12" x 3/4" (2); Masonite 7" x 12" x 1/8" (2);
2 filament bulbs and sockets with wire; Old auto lens;
2-way switch; Insulated wire; Tin Clean; 11 small wood
screws; Glue; Tape; Solder Equipment; Tin Snips

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP
WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL
TIMES.

1. Cut 3/4" wood to size and cut out parabolic shape.
2. Cut masonite to size.
3. 3/4" wood pieces (Cut strips of tin and fasten with small tacks).
4. Drill hole for wire as shown. Solder wire to socket for ground.
5. Push wires through hole and fasten socket with small screws.
6. Connect wires to 2-way switch and fasten.
7. Screw masonite to wood.
8. Insert bulb.
9. Connect to battery.
10. Darken room
11. Place assembly against blackboard sideways (support it).
12. Throw switch and notice light ray along board (chalk-board for better results).

Title: LAB--The Headlight Lamp

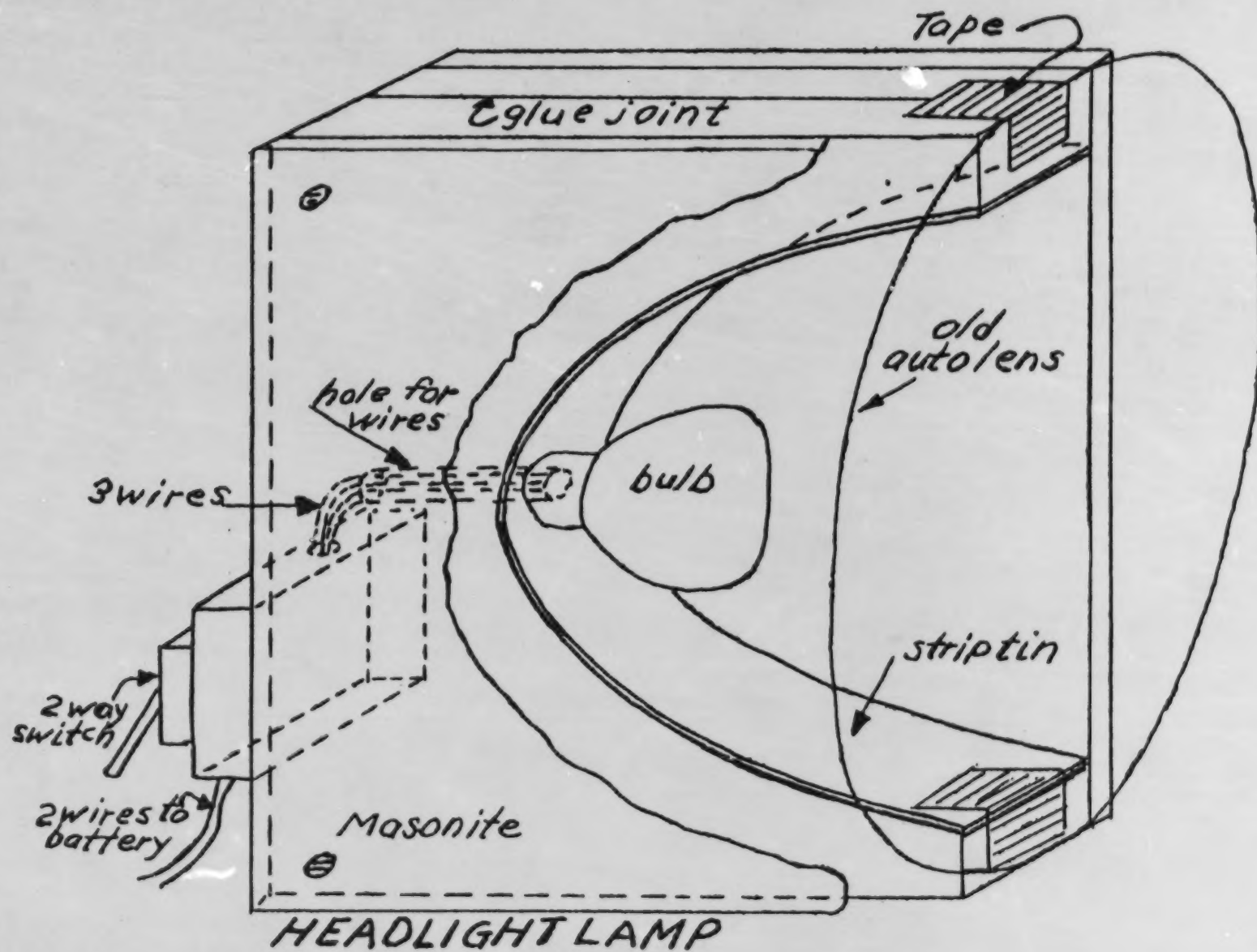
PAGE TWO

13. Tape lens in place and notice the beam.
14. Tape lens in other positions and notice the beam.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED
AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Conclusions:

1. Explain why the higher filament shows high on the road.
Draw a simple sketch to show the path of light in each case.
2. Draw a simple sketch to show how the beam of light is bent as it goes through the uneven surface of the lens.
3. Explain why a deep parabola will give more intense light than a shallow one.



Title: LAB-- Polarization of Light

Unit: Light

Course: Physics

Purpose:

To observe some ways in which light may be polarized and to determine some uses of polarized light.

Materials Required:

Two Polaroid disks; sample of calcite; section of ferrotype plate; 10 to 12 glass plates (about 5 cm or 2 in. square); cellophane strips (mounted in a step pattern between 5-cm square glass plates); U-shaped piece of transparent plastic; glass from broken molded bottle.

Information:

Light waves which vibrate in only one plane are said to be POLARIZED. There are several natural crystals, such as calcite and tourmaline, which possess the property of polarizing light which passes through them. Light may be partially polarized by reflection. POLAROID is a synthetic material which is used to polarize light.

Through the use of polarized light and the means of detecting it, scientists are able to make observations that cannot be made with ordinary light. Polarized light is used in identifying certain chemical compounds, in detecting strains in structural materials and in determining the thickness of crystals and fibers. Polaroid is used in some sunglasses and types of reading lamps to reduce glare.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Look through one of the Polaroid disks at one of the walls in the lab or at the shiny lab bench top. Rotate the disk. Does the intensity of light vary?

Repeat the procedure with the other disk. Do you get the same results?

How does the intensity of light, coming through the single disk, compare to that directly reaching your eye?

Title: LAB--Polarization of Light

PAGE TWO

The light coming through the Polaroid disk is PLANE-POLARIZED. In other words, the light waves coming through are all vibrating in the same plane.

2. Hold both disks together and rotate one of them while looking at the wall or bench top. What do you observe?

How much do you have to turn one disk to go from maximum to minimum brightness?

When the Polaroid disks are placed so that a minimum of light is allowed to pass through, the disks are said to be CROSSED. Explain why crossed polarizers transmit a minimum amount of light.

3. Look through a transparent piece of calcite at this dot. What do you see?

Turn the crystal slowly. What movement, if any, do you observe?

Look through a single rotated Polaroid disk at the images in the crystal. What happens? Explain.

4. Place a piece of ferrotype plate on your lab bench. Set it in a position where the maximum amount of light from the window is reflected from the surface of the plate as "glare". Examine the glare through a single rotated Polaroid disk. Is the glare light polarized? How do you know?

Title: LAB--Polarization of Light

PAGE THREE

Stack 10 to 12 glass plates and set up as above. What do you observe? Explain.

Hold the Polaroid disks, one over each eye, oriented so that their transmitting plane is at right angles to the plane in which the glare is polarized. Compare the glare through the Polaroid disks with that you see without them.

What practical application does the observation you just made have?

5. Cross the two Polaroid disks and place between them the glass plates containing the cellophane strips of varying thickness (i.e., mounted in steps). Rotate the glass plates until you observe the brightest colors. How does the brightness of the color vary from the thin strips to the thick ones? Describe and use a diagram or sketch if desired.

6. Examine the U-shaped piece of transparent plastic between crossed Polaroid disks. What do you observe?

Squeeze the open ends of the piece of plastic between your fingers. What do you observe?

Title: LAB--Polarization of Light

PAGE FOUR

How do colors help to detect the places where strain is greatest?

Examine a piece of glass, broken from a molded bottle, between crossed polarizers. Are there strains in the glass? Explain.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--White Light

Unit: Light

Course: Physics

Purpose:

To prove that white light is produced

- a. by the colors of the spectrum
- b. by complimentary colors

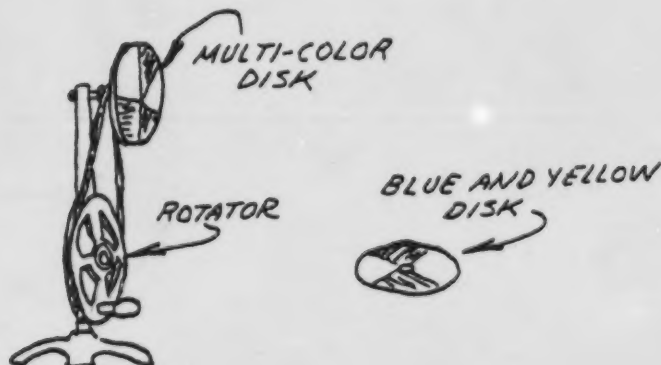
Materials Required:

Rotator, Color disk (multi-color), Color disk (blue and yellow), Blue and Yellow water colors.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Attach the multi-colored disk to the rotator.



2. Rotate rapidly and note the color.
3. Attach the yellow and blue disk.
4. Rotate rapidly and note the color..
5. Mix a few drops of blue and yellow water colors and note the results.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--White Light

PAGE TWO

Conclusions:

1. What colors appeared when the multi-colored disk was rotated?
2. What colors produce white light?
3. Would colored lights from spotlights produce the same effect?
4. What color was apparent when the blue-yellow disk was rotated?
5. What are complimentary colors?
6. What color appeared when the blue and yellow water colors were mixed?
7. Explain the production of color by addition.
8. Explain the production of color by subtraction.

Title: LAB--Color and Lighting

Unit: Light

Course: Physics

Purpose:

To learn the principles that govern the combining of colored lights and pigments.

Materials Required:

Light source with red, yellow, green and blue filters; samples of cloth or paper (such as construction paper) red, orange, yellow, green, blue, and violet; paint (such as poster paint) red, yellow, green and blue; glass rod or stick; glass plate; cardboard.

Information:

The use of colors and lighting in any type of design work is very important. Proper use of colors and lighting can add to the effectiveness of a display or a place of business.

The fashion designer must choose colors wisely to suit the taste of customers. Proper lighting must be selected so as not to detract from displays.

A restaurant owner or beauty shop manager must also choose proper color and lighting to convey the feeling of cleanliness and comfort. The lighting selected must not, in any way, hinder the effects of the colors selected.

In any type of design or display, colors must be matched and blended and lighting selected to compliment, and not change, the purpose for which the colors were selected.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Fasten the colored cloth or paper samples to a piece of cardboard. Then shine the light source on the samples, starting with no filter and then using each colored filter in turn. Observe the different effects and record the colors produced in the table, below.

Title: LAB--Color and Lighting

PAGE TWO

COLOR OF LIGHT	COLOR OF SAMPLES					
	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET
WHITE						
RED	Red					
YELLOW			Yellow			
GREEN				Green		
BLUE					Blue	

2. Shine the light source, using different colored filters so that the various colors overlap. Observe the color that results where they overlap and record in the table below.

	RED	YELLOW	GREEN	BLUE
RED	—			
YELLOW		—		
GREEN			—	
BLUE				—
RED, BLUE	—			—

3. Using a glass rod or stick, place a drop of paint on a glass plate. Combine with another color of paint and record the resulting color in the table below. Remember to clean off the rod and plate after each use so as not to contaminate the paint.

	RED	YELLOW	GREEN	BLUE
RED	—			
YELLOW		—		
GREEN			—	
BLUE				—
RED, BLUE	—			—

Title: LAB--Color and Lighting

• PAGE THREE

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS
PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. Why does the red sample appear dark, almost black, under the blue light? Is this color subtraction or addition?
2. When purchasing clothing, should you pay attention to the type of lighting used in the store?
3. If you were decorating a restaurant and decided to use yellow table cloths, would it be wise to light the room with a fluorescent bulb which gave off a blue glow? Why? What effect would this have on the customers?
4. What are the three primary colors of light? of pigment? What relationship is there between them?

Title: LAB--Color and Lighting

INSTRUCTOR'S NOTES

When performing the step involving the combining of colored light, it may be helpful to use three projectors. If this is not possible, three flashlights may also be used.

It may be helpful to have the students bring in actual displays or samples from shop to study the effect of lighting on them.

COMMENTS:

Title: LAB--Spectra of Elements

Unit: Light

Course: Physics

Purpose:

To observe the spectra of some elements and gain an understanding of how it can be used to identify the composition of substances.

Materials Required:

- Simple spectroscope, bunsen burner, incandescent lamp, nichrome or platinum test wires, chloride salts of lithium, sodium, potassium, calcium, strontium and copper.

Information:

When a substance is heated, the atoms of the substance absorb kinetic energy by collision with the fast moving particles of the flame. The atoms of the substance are then moving at high speeds and frequently collide. The energy exchanged during a collision often results in an electron within an atom being raised from a lower energy level of a higher energy level. The electron returns almost at once to its original energy level. According to the law of conservation of energy, in this process the electron must release the same amount of energy it absorbed when it was raised to the higher energy level. It does so by emitting one or more photons of light or other electromagnetic radiation.

Since the structure of atoms differ from element to element, the possible transitions between energy levels within atoms of each element is also distinctive. Thus, each element is capable of displaying an array of colors (spectrum) that is characteristic of that element alone. By observing the light given off by a heated substance, one can identify the elements it contains.

Incandescent solids and liquids give off continuous spectra. By observing the spectrum of an incandescent filament of a lamp with a spectroscope, one can observe a continuous spectrum. Such a spectrum contains a great many wavelengths of light so close together as to be indistinguishable.

Incandescent gases give off relatively few wavelengths of light. Thus, the characteristic spectra of elements which make up the gas are relatively simple. Sodium, for example, gives off bright wavelengths of yellow light which, when observed through a spectroscope, appear as two bright lines of yellow light. These lines immediately identify the element sodium.

Title: LAB--Spectra of Elements

PAGE TWO

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Practice using the spectroscope by looking at an incandescent lamp. The spectrum should appear to either side of center (be certain that you are looking into the correct end). Adjust the spectroscope until the continuous is horizontal and clear.
2. Ignite and adjust the burner until a clean, blue flame is obtained.
3. To test sodium chloride, use the wire loop included in the bottle to pick up some solid sodium chloride. Hold the loop in the flame until the sodium chloride melts. Observe the spectrum of sodium through the spectroscope. You may see a long broad band image of the wire if it is glowing. Ignore this image.
4. Be careful to return the wire to its proper bottle. Do not mix wires. This will cause contamination. If you do make a mistake, hold the wire in the flame until all the salt on the wire has been burned off.
5. Test each salt in its turn and sketch the line spectrum emitted by each in the table below. A sketch of the major lines will do. Label the colors of as many lines as you can.

CHLORIDE SALTS OF...	SPECTRAL LINES OF ELEMENTS						
	RED	ORANGE	YELLOW	GREEN	BLUE	INDIGO	VIOLET
SODIUM							
LITHIUM							
POTASSIUM							
CALCIUM							
STRONTIUM							
COPPER							
COPPER - LITHIUM (EQUAL)							
COPPER - LITHIUM (UNEQUAL)							

Title: LAB--Spectra of Elements

PAGE THREE

6. Mix equal amounts (small amounts) of two salts, copper chloride and lithium chloride. Using an extra test wire, hold a loopful of the mixture in the flame and observe the resulting spectrum. Sketch the results in the table. Do you distinguish the characteristic lines of each element? Does it contain a combination of the copper and lithium lines?
7. Try mixing unequal amounts of the two salts. Add only a trace of lithium chloride to some copper chloride. Can you observe the characteristic colors of each element by looking at the color of the flame? Can you detect the presence of lithium by using the spectroscope?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. In steel mills, large amounts of scrap steel of unknown composition are melted together to make new steel. Explain how the laboratory technician can tell exactly what is in each batch of steel so that the composition may be adjusted.
2. How do you know that the bright yellow lines you observed when looking at the sodium chloride are due to the sodium and not to the chlorine in the compounds?

Title: LAB--Color Blindness, Deafness, Blindness

Unit: Light

Course: Physics

Purpose:

To witness the effects of color blindness, deafness, and blindness.

Materials Required:

Slide projector (or film strip projector with slide projection apparatus); Wescott Color Slides Set (for testing color blindness); projection screen; 3 x 5 index cards (or paper of similar size); clock or other timing device; eye patches and cloth for blindfolds).

Information:

FOR THE INSTRUCTOR:

The format for this lab is different from other labs in this Project Book. It is presented for the instructor, rather than for the student as in previous labs.

The purpose of this lab is to actually get the students to witness some handicaps such as color blindness, deafness, and blindness. At the conclusion of this lab, the students are to respond either verbally (via a group discussion) or on paper (via a brief report) to express their feelings in regard to this lab.

Part 1.--Conduct a color blindness test using the Wescott Color Slides Set. Have the students take the test. Discuss the problems of color blindness (bring in trade areas or areas of life where it may be a critical problem). Discuss the degrees of color blindness and methods of checking for it. Show the students, via the Set, what the "world of color" looks like to a color blind person.

Part 2.--Prepare a series of statements on 3 x 5 index cards (or paper of similar size). The statements should be conversational or communicative in nature--for example, "Stop by the gas station to get some gas"; "Go to the store and get a loaf of bread"; etc. The length and complexity of the statements are left to the discretion of the instructor. Using this as a guide, distribute the cards to pairs of students and have one communicate the contents of the card in a prescribed time limit. Switch cards and/or switch partners to insure that everyone has

Title: LAB--Color Blindness, Deafness, Blindness

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had an opportunity to act as sender and receiver more than once. The catch to this exercise is that the contents of the cards cannot be communicated by speaking--other methods have to be found and tried. Accuracy of communication should be discussed. Methods of communicating should also be discussed.

Part 3.-Pair off the students. Have one student in the group cover the eyes and wrap a cloth over them for a blindfold. The other student will act as a guide. Have the groups of students circulate around the school building or around the campus to feel the full effect of negotiating without sight. Each student should keep on the blindfold for at least fifteen minutes or longer and then switch roles with the student that had acted as the guide. After a prescribed time has elapsed, have all students return to the class or lab. Discuss the experiences of the students. Discuss the problems encountered. Discuss the frustrations.

ELECTRICITY

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170.

Title: LAB--Magnetic Fields

Unit: Electricity

Course: Physics

Purpose:

To observe magnetic field lines around magnets and to understand field interactions between magnets.

Materials Required:

2 bar magnets; piece of soft iron; iron nail; small compass; iron washer; string; iron filings; thin sheet of cardboard (or paper or glass plate); paper clips.

Information:

Although many substances exhibit slight magnetic properties, only iron, cobalt, and nickel make strong permanent magnets. Magnets composed of these substances (or of alloys containing these substances) are capable of attracting or repelling other magnets through a distance without any apparent connection between the interacting magnets. If any object contains iron, cobalt, or nickel and a magnet is brought close to it, the magnet will induce magnetism in the body and will then interact with it.

If a magnet is suspended, free to rotate in a horizontal plane, the magnet will come to rest in a roughly north-south position. The end of the magnet that points toward north is called the "north-seeking pole" (N) of the magnet, while the opposite end is called the "south-seeking pole" (S). A compass is a small magnet, free to pivot in a horizontal plane.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Check the polarity of your bar magnets. Using a string, suspend the magnets (one at a time), being careful they are not suspended near any iron or steel objects. The pole marked "N" should point north when the magnet comes to rest.
2. Place a bar magnet on the lab bench and cover it with the thin piece of cardboard (or other material provided by your instructor). Gently and evenly, sift iron filings on top of the cardboard. Tap the cardboard lightly with your fingers until the filings form a definite pattern. Draw the pattern below.

Title: LAB--Magnetic Fields

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Note that the filings seem to follow definite lines from one end of the magnet to the other. These are called magnetic field lines. Note also that the field lines never overlap. CAREFULLY return the iron filings to the container.

3. Place both bar magnets on the lab bench with the "N" pole of one magnet about 4 cm ($1\frac{1}{2}$ in.) from the "N" pole of the other. Cover both bar magnets with the thin cardboard and sprinkle the filings onto the cardboard. Tap the cardboard lightly. Draw the resulting pattern below:

4. Place unlike (N-S) poles facing each other in a similar way to that followed in Step 3. Repeat the procedure and draw the resulting pattern below:

INSTRUCTOR'S INITIALS _____

5. Arrange the piece of soft iron between unlike poles of the bar magnets, leaving about 1.5 cm ($\frac{5}{8}$ in.) between each magnet and the piece of iron. Follow the procedure in Step 3, and draw the resulting pattern below:

Title: LAB--Magnetic Fields

PAGE THREE

6. Remove the piece of soft iron from between the two magnets and replace it with the iron washer. Cover the magnets and washer with the thin cardboard and sprinkle filings on it. Tap with your finger until a definite pattern forms. Is there evidence for the existence of a magnetic field inside the washer? Explain.

Draw the pattern below:

7. In Step 5, magnetism was induced in a piece of soft iron without bringing the iron in contact with the magnet. Another way to induce magnetism in iron is to place it directly on the magnet.....Test an iron nail for magnetism by touching it to some paper clips. Test the nail again while it is attached to one end of a magnet. What do you observe in each case?

Suspend the second magnet with a piece of string. With the iron nail still at one end of the first magnet, test the free end of the nail for polarity. Compare the polarity of the free end of the nail with the polarity of the end of the magnet to which it is attached. Are they the same or opposite? Explain.

8. The direction of a magnetic field is the direction taken by the north-seeking pole of a tiny magnet placed in the field. In general, we say that the magnetic field runs out of the north-seeking pole and into the south-seeking pole of the magnet. To test this, test the field of one of the magnets by using a small magnetic compass. Place the compass at one corner of the "N" pole and note the direction in which the north-seeking pole of the compass points. Slowly move the compass in a flattened arc from the "N" pole to the "S" pole of the magnet. What do you observe?

Title: LAB--Magnetic Fields

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Place the compass between the "N" pole of one bar magnet and the "S" pole of the other. What do you observe?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Magnetic Fields

INSTRUCTOR'S NOTES

Some wristwatch movements are affected by magnetic fields. Have students remove their watches and place them a safe distance from the magnets.

Keep iron filings in shaker cans which can be closed when not in use.

Have students handle iron filings carefully, avoiding getting the filings directly on the magnet(s).

COMMENTS:

Title: LAB--Magnetic Field and a Current-Bearing Wire

Unit: Electricity

Course: Physics

Purpose:

To study the magnetic fields around current-bearing wires.

Materials Required:

DC power supply (or three 1.5 volt dry cells); 4 compasses; piece of cardboard with hole in center; about 1.5 m of insulated copper wire; large iron nail (or other iron) for use as magnet core; knife switch; ring stand; ring stand clamp; bar magnet; iron filings; box of paper clips.

Information:

The Danish scientist Hans Christian Oersted discovered that when a current flows through a wire, a magnetic field appears around the wire. The magnetic field around a current-bearing wire has all the properties of the magnetic field around a permanent magnet.

The rule that the direction of a magnetic field is from "north to south" has little meaning in relation to the field around a straight piece of wire. A more useful rule states that the field takes the direction of a tiny magnet (magnetic compass) placed in the field as indicated by the north-seeking pole of the small magnet. The north-seeking poles of the compasses indicate the magnetic field around the wire takes the form of circular loops perpendicular to the wire.

A faster method of determining the direction of the field around a wire is the left-hand rule which states: The direction of the field around a wire is found by grasping the conductor in the left hand with the thumb pointing in the direction of current (electron) flow. The fingers will circle the conductor in the direction of the magnetic field.

An electromagnet can be made by winding a current-bearing wire around a soft iron core. The coil of wire wrapped around the core is called a SOLENOID. The magnetic field around the wire windings is collected by the iron core. This results in a strong magnet.

The polarity of an electromagnet is determined by another left-hand rule. It states: The coil is grasped with the left hand in such a way that the fingers of the hand coil around the loops in the same direction in which the current is flowing; the thumb points toward the "N" pole of the magnet.

Title: LAB--Magnetic Field and a Current-Bearing Wire

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Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Clamp the cardboard horizontally to the ring stand. Arrange the wire so that it passes vertically through the hole in the cardboard. Connect the wire in series with the switch and the dry cells (use at least three dry cells or between 4 and 6 volts from the DC power supply). Connect the upper part of the wire to the negative terminal of the voltage source so that the current flows down the wire.
2. Place the four compasses around the wire at right angles to each other (at each of the four quadrants) on the cardboard.
3. Close the switch for ONLY AN INSTANT because the wire is a short circuit across the cells. Note the direction of the field as indicated by the north-seeking poles of the compass needles. Record the results below:
4. Reverse the connection to the current source so that the negative terminal is now connected to the lower part of the wire, and current flows up the wire. Close the switch once again (remember, for ONLY AN INSTANT) and note the direction of the field around the wire. Record results below.
5. Remove the compasses from around the wire and carefully sprinkle iron filings on the cardboard around the wire. Close the switch FOR AN INSTANT and tap the cardboard with your fingers. Turn off the current when the filings have taken the shape of the field. Record your observations below:

Title: LAB--Magnetic Field and a Current-Bearing Wire

PAGE THREE

6. Remove one dry cell from the circuit (or lower the voltage from the power supply) and tap the cardboard to disarrange the iron filings. Close the switch FOR AN INSTANT and tap the cardboard. Observe the field. Remove another dry cell (or lower the voltage) and repeat the procedure. Record your observations:

Instructor's Initials _____

7. Remove the wire from the ring stand and wind loops of the wire around the iron core until the core is about half wound. Connect one dry cell to the switch and electromagnet in SERIES. Open the box of paper clips and briefly turn on the current, watching to see how many paper clips the magnet will pick up. Open the switch. What did you observe? Explain.
8. Wind several more turns of wire around the iron core (double the number of turns if possible), then turn on the switch and try picking up the paper clips again. What did you observe this time? Explain.

Title: LAB--Magnetic Field and a Current-Bearing Wire

PAGE FOUR

9. Add a dry cell in SERIES with the first dry cell and again try picking up the paper clips. Record what you observed below:

10. Have your lab partner hold the bar magnet in one hand. With the electromagnet in series with ONE dry cell, test one of its ends for polarity by observing if it attracts or repels the "N" pole of the magnet. Check the left-hand rule to see if it agrees with the polarity of the electromagnet. Record your results below:

CLEAN UP YOUR WORK STATION. BE CERTAIN TO PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Questions:

1. What three factors determine the strength of an electromagnet?
2. Explain why an electromagnet is called a temporary magnet.
3. Explain why a bar magnet is called a permanent magnet.
4. How can the direction of a magnetic field around a wire be determined?

Title: LAB--Magnetic Field and a Current-Bearing Wire

INSTRUCTOR'S NOTES

Insist that students open the switches as soon as possible during each part of the lab exercise. All circuits involved are short circuits across the voltage source.

COMMENTS:

Title: LAB--The Electromagnet

Unit: Electricity

Course: Physics

Purpose:

To show how to make an electromagnet and what it can do.

Materials Required:

Iron rod 1/2" diameter, 5" long; 15 ft. of #24 Insulated Copper Wire; Storage Battery; Iron filings; Compass; Bar Magnet.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Cut iron bar to size.
2. Wind wire around bar leaving about a foot at each end.
3. Scrape ends clean and connect to a battery.
4. Place an electromagnet on a paper and sprinkle iron filings around it. Trace the lines of force of the filings. Reverse the current and describe what happens.
5. Place a compass near each end of the iron core and describe what happens. Reverse the current, do the same and describe what happens.
6. Place each end of the bar magnet against one end of the electromagnet. Explain what happens in each case.
7. Explain how you can demagnetize a steel bar magnet with a D.C. current. Try it.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--The Compass

Unit: Electricity

Course: Physics

Purpose:

To determine the geographical direction of a given line.

Materials Required:

Compass; Simple sighting equipment

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Check the compass with a line pointing true north. This line should have been previously established by sighting the north star which will be considered near enough to true north for this experiment. Record the angle of declination of the magnetic north pole from the geographical north pole in the data table.

The angle of declination is _____.

2. Set the center of the compass over any convenient given line (a line parallel to one wall of the science room may be used) and adjust the compass so that the "N" is under the north-seeking part of the compass needle. Read the direction of the given line.

The compass reading is _____.

3. Allow for the declination, determined in the first part of this experiment, and record the true geographical direction of the given line.

The true geographical direction is _____.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____.

Questions:

1. Why does the true geographical direction differ from the compass reading.
2. Is the true direction determined the same way in all parts of the country? Explain.

Title: LAB--Static Electricity

Unit: Electricity

Course: Physics

Purpose:

To determine whether or not static electricity may be stored and built up to a high potential.

Materials Required:

An electrophorus; Piece of fur; Leyden jar; Discharger

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Ground the outside foil of the Leyden jar.
2. Rub the bottom or wax plate of the electrophorus with a piece of fur, thereby charging it.
3. Place the metal disk on the plate and touch the metal plate with your finger.
4. Remove the metal disk and bring it near enough to the knob of the Leyden jar so that a small spark will jump between the two.
5. Repeat operations 3 and 4 several times.
6. Connect the outside foil and the knob by using the discharger.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. What happens to the charge that is produced on the metal disk of the electrophorus when it is brought near the knob of the Leyden jar?
2. When the Leyden jar was discharged, was there evidence that the several charges from the electrophorus had been stored in the Leyden jar? Explain.
3. A number of conducting plates separated from one another by an insulator is called a condenser. Does the Leyden jar meet these specifications?
4. What would you say was the action of a condenser?

Title: LAB--The Effect of Lightning on Autos

Unit: Electricity

Course: Physics

Purpose:

To show that the electrical charge of a conductor is confined to its outer surface.

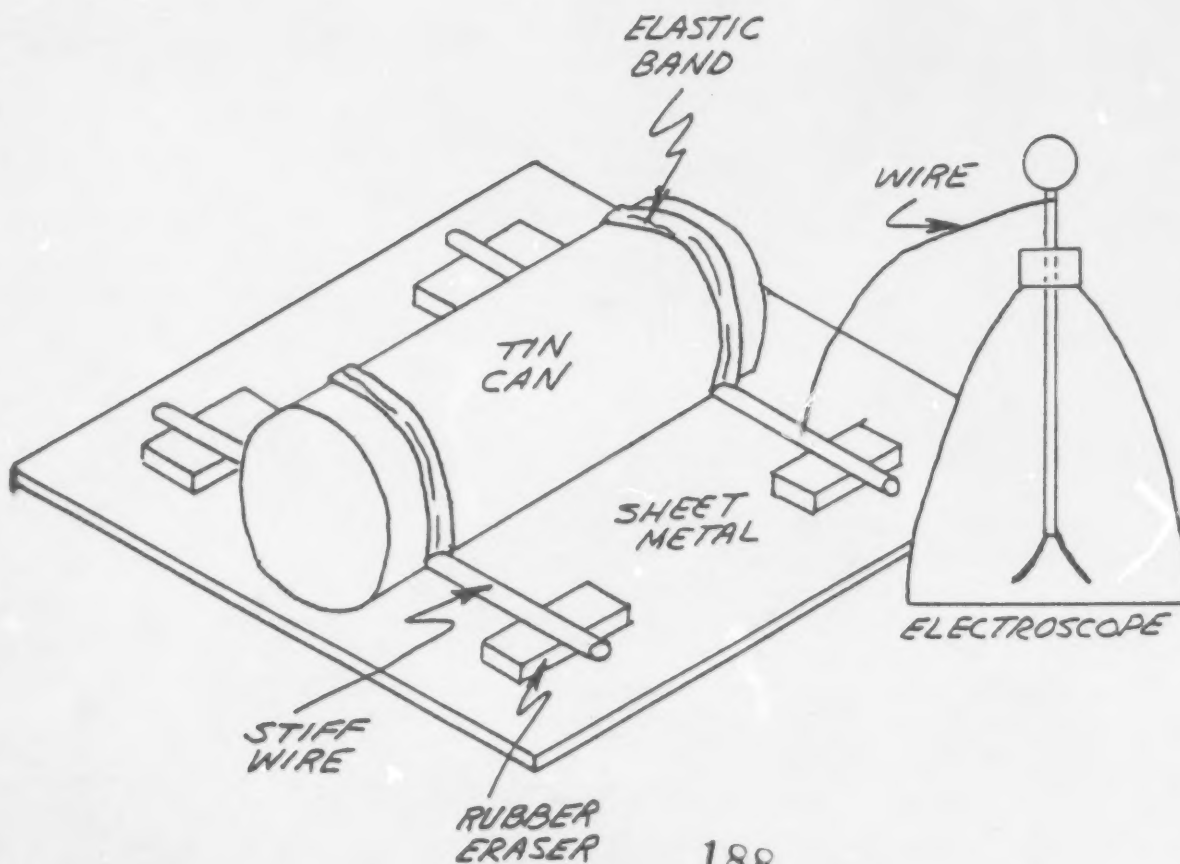
Materials Required:

Tin can; Stiff wire (2) 6" long; 4 flat rubber erasers; Elastic bands (2); Static charging apparatus; Static machine; Electroscope; Copper wire; Metal sheet 8" x 8".

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Cut the ends of the tin can with a can opener (leave no sharp edges). Attach stiff wires with elastics as shown in diagram.



Title: LAB--The Effect of Lightning on Autos

PAGE TWO

Procedure (Continued)

2. Place on erasers.
3. Tie wire to electroscope as shown.
4. Charge the tin can.
5. Touch wire from the electroscope to outside of can, note gold leaves.
6. Recharge the can.
7. Touch wire to inside of can and note the gold leaves.
8. Connect one terminal of the static machine to sheet metal.
9. Place under can assembly.
10. Connect wire to other terminal of static machine and hold end of wire about a half inch over can with an insulator.
11. Turn static machine and note the sparks.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. Explain why the electroscope showed no effects when the inside was tested.
2. Why can't the electroscope hold the charge when wire is attached?
3. Would the spark jump from the rim to the road when a car is hit by lightning if the car had polar grip tires? Explain why?
4. Explain what happens when you touch the inside of the can and the sheet metal when the static machine is turned on.

Title: LAB--The Voltaic Cell

Unit: Electricity

Course: Physics

Purpose:

To study the construction and action of a simple cell.

Materials Required:

Glass jars or beakers; plates of various metals (copper, zinc, carbon, lead, iron); dilute sulfuric acid; wire; galvanometer.

Information:

Between two unlike metals in a conducting solution there is a difference of potential or electromotive force. This is the principle of the voltaic cell. If the metals are joined by a conductor, electric current flows. The metal that dissolves most readily in the electrolyte (the conduction solution) becomes the negative electrode.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Fill a glass three-quarters full with dilute sulfuric acid. REMEMBER TO USE CAUTION WHEN HANDLING ACIDS.
2. Immerse a copper and a zinc plate in the solution, being careful to keep them apart.
3. Attach wires to the zinc and the copper plates, connecting the other ends of these wires to a galvanometer.



4. Observe any movement of the galvanometer pointer, noting the direction it moves. Record in table.

Title: LAB--The Voltaic Cell

PAGE TWO

5. Repeat the procedure for other combinations of metals as indicated in the table, and record observations as before.

CLEAN UP YOUR WORK STATION. BE CERTAIN TO PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

PLATE 1	PLATE 2	GALVANOMETER DEFLECTION	
		RIGHT	LEFT
COPPER	ZINC		
COPPER	COPPER		
ZINC	ZINC		
CARBON	ZINC		
CARBON	LEAD		
COPPER	IRON		

Conclusions:

1. What action was observed when the copper and zinc plates were immersed in the acid?
2. When the galvanometer was connected, was any movement of the needle noted?
3. Was electricity produced? Explain.
4. May two plates of the same material be used in an electric cell? What combinations of plates that you tried may be used? Which was the best combination?

Title: LAB--The Storage Cell

Unit: Electricity

Course: Physics

Purpose:

To study the construction and action of a storage cell.

Materials Required:

Glass jars or beakers; lead plates (strips); dilute sulfuric acid; wire, galvanometer; DC current source.

Information:

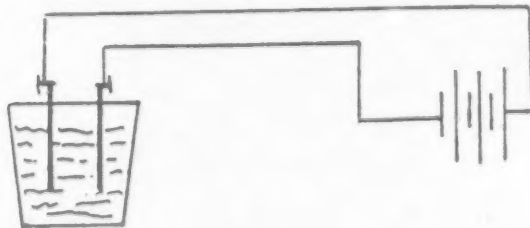
The primary voltaic cell (refer to LAB--The Voltaic Cell) has one important shortcoming. When the negative electrode is completely dissolved in the electrolyte, or eaten away, the cell stops functioning. The process cannot be reversed. The electrode cannot be replaced by "recharging", and the cell must be discarded.

Storage cells can be recharged. Such cells are called secondary cells. They are widely used in cars, trucks, planes, etc.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Fill a glass jar three-quarters full with dilute sulfuric acid. USE CAUTION WHEN HANDLING ACIDS.
2. Immerse two lead plates in the solution, making certain they are kept apart. Note any action that takes place on the plates.
3. Connect wires to the plates and to the galvanometer and note any movement of the galvanometer needle.
4. Disconnect the galvanometer and connect the plates to a DC current source for a few minutes. Again, note any action that takes place in the cell. Particularly note the color of the plates.



Title: LAB--The Storage Cell

PAGE TWO

5. Disconnect the DC source and again connect the cell and the galvanometer. Note the action of the galvanometer needle and any action in the cell. Leave connected for several minutes.

CLEAN UP YOUR WORK STATION. BE CERTAIN TO PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. What action took place when the lead plates were first immersed in the solution?
2. How did the galvanometer act when first connected?
3. What action was noted after the DC source had been connected for a few minutes?
4. How did the galvanometer act for the second time it was connected? What did the galvanometer show after it had been connected for a few minutes?

Title: LAB--Electroplating

Unit: Electricity

Course: Physics

Purpose:

To study the principles of electroplating.

Materials Required:

Two carbon rods; strip of clean metallic copper; copper sulfate solution; DC current source (such as two dry cells); glass jar or beaker; wire; steel wool; small metal object (such as a brass key).

Information:

One of the most important applications of the chemical effects of an electric current is electroplating. Electroplating is a means by which one can coat materials with almost any metal.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Connect the DC current source (if using dry cells, connect them together in series) to clean carbon rods. Place the rods in a glass jar containing the copper sulfate solution. Make certain that the rods are separated.

INSTRUCTOR'S INITIALS _____

2. Allow current to flow for about 3 minutes. Then remove carbon rods and examine them. What changes do you observe on the positive rod?

What changes do you observe on the negative rod?

3. Reverse the wire connections at the source of current so that the negative rod is now positive and vice versa. Allow current to flow for about five minutes. Remove the rods and examine them. What do you observe?

Title: LAB--Electroplating

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4. Copperplate a small, clean metal object (such as a brass key). Polish the object and the copper strip with the steel wool and wash them in water.
5. Suspend the object from the wire leading to the NEGATIVE terminal of the current source. Connect the copper strip to the wire leading to the POSITIVE terminal.
6. Immerse the object and the copper strip in the copper sulfate solution. Be certain that they are separated. Allow current to flow.
7. From time to time, remove the object and polish lightly with the steel wool. What do you observe at each electrode?

CLEAN UP YOUR WORK STATION. BE CERTAIN ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. To what terminal of a cell must the object to be plated be connected?
2. Can alternating current be used for electroplating? Explain.
3. Where does the copper deposited on the metal object come from?
4. What would happen if you continued to electroplate with the two carbon rods?
5. What is the purpose of the copper strip attached to the positive terminal when plating the metal object?
6. How can a non-conducting object, such as a baby shoe, be prepared so that it may be copperplated?

Title: LAB--Meter Operation

Unit: Electricity

Course: Physics

Purpose:

To learn how various meters are used in making electrical measurements and to practice reading different scales.

Materials Required:

Ruler or straight edge (for demonstration purposes a voltmeter, ammeter, ohmmeter and multimeter).

Information:

Knowledge of the function and proper use of meters for making electrical measurements is very important. These meters are often very expensive, and if not used properly they can be easily damaged.

An electric current is simply the number of electrons passing, or flowing by, a given point in a given time. To measure current, an instrument called an AMMETER is used. An ammeter is always connected in SERIES in a circuit so that all current to be measured passes through it.

A VOLTmeter measures the electromotive force (E.M.F.), or difference in electrical potential (sometimes called electrical pressure), that make the electrons flow. A voltmeter is wired in PARALLEL so that it measures the "difference" in potential between two points in a circuit.

Opposition to the flow of electrons is called resistance. The resistance of electrical components in a circuit can be measured with an OHMMETER. Since the power to operate the ohmmeter is self-contained (e.g., it may have a battery) all power from the circuit must be removed before the meter is connected into the circuit.

Many meters would be required to measure the wide range of voltage, current and resistance. To overcome this, some meters have several ranges or scales. This permits it to be used for many values of measurement. Always start with the HIGHEST SCALE and drop down, if needed, until a full-scale reading is achieved, (this is the more accurate reading).

A MULTIMETER is a single meter which can be used to measure all three quantities (current, voltage and resistance). When meters which are capable of measuring more than one electrical property are used the FUNCTION SWITCH must be properly set prior to use.

When using DC meters, always observe polarity. Never use a DC meter to measure AC. Make certain the meter is zeroed-in before you start.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. On the following page is a picture of a meter. It will be used to practice reading meters. The index scale shown at the top of the meter is not part of a normal meter--it has been added to make use of the illustration more convenient.
2. On the index scale, each mark between the numbers is equal to two tenths (0.2). To use the illustration to practice meter reading, place a ruler or straight edge across the page from the dot in the center of the circle at the bottom of the illustration, to the appropriate index number at the top of the meter. Read the value on the proper scale where the ruler or straightedge intersects.
3. Assume the selector switch to be in the position specified in the table, Page Four (so proper scale is read). Record the appropriate meter readings in the table. After you have completed this portion of the exercise have it checked by your instructor. INSTRUCTOR'S INITIALS _____.
4. Examine the meters provided by your instructor. Look at the scales. Examine the scale ranges. Look at the lead connections. Get to "know" the meters.
5. Describe how to use each meter. Include information such as what it measures, how it is connected to circuit, whether power is on or off, is polarity to be observed, what scale is used first, etc.

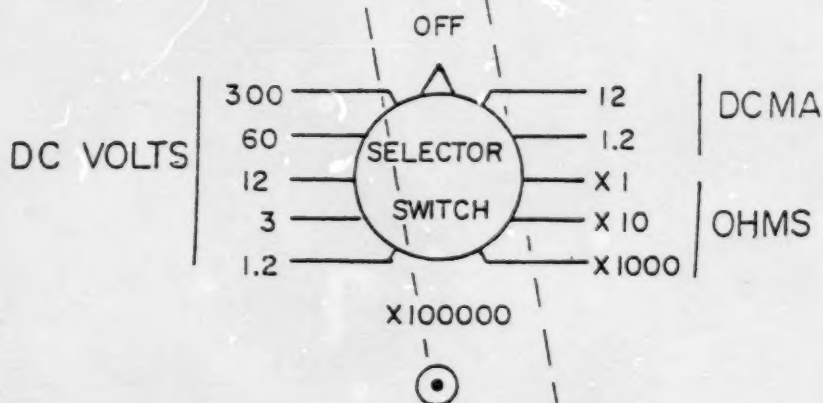
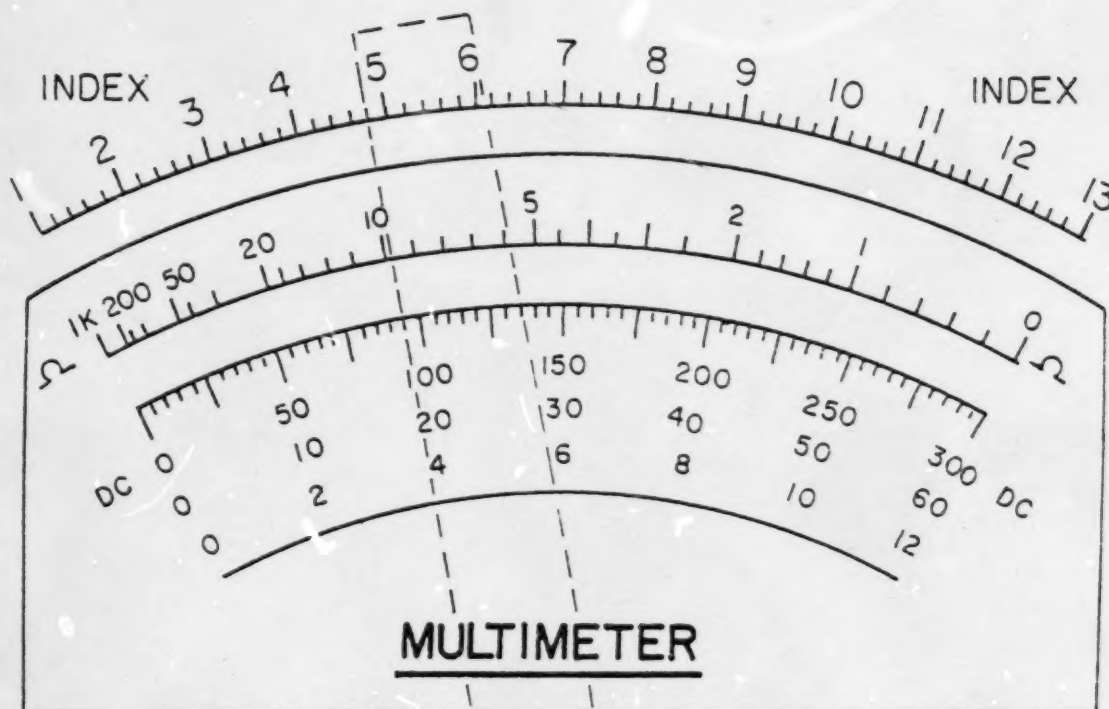
AMMETER--

VOLTMETER--

OHMMETER--

MULTIMETER--

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.



SELECTOR SWITCH	INDEX	METER READING	SELECTOR SWITCH	INDEX	METER READING
300 VOLTS DC	3.0		/	10.6	
	6.2			4.8	
	10.0		10	4.0	
	5.8			9.2	
60 VOLTS DC	2.0		X 1000	2.0	
	9.4			6.6	
	7.4		X 10000	8.0	
	11.4			4.0	
12 VOLTS DC	4.4		12 DC mA	9.0	
	9.2			3.2	
	5.8		1.2 DC mA	9.0	
3 VOLTS DC	2.0			5.2	
	11.0		1.2 DC VOLTS	3.0	
	4.6			5.4	

Title: LAB--Meter Operation

INSTRUCTOR'S NOTES

Due to the nature of this lab exercise, it may be performed in a regular classroom.

If desired, some circuits or components can be set up so student can actually use the various meters.

COMMENTS:

Title: LAB--Electrical Circuits I

Unit: Electricity

Course: Physics

Purpose:

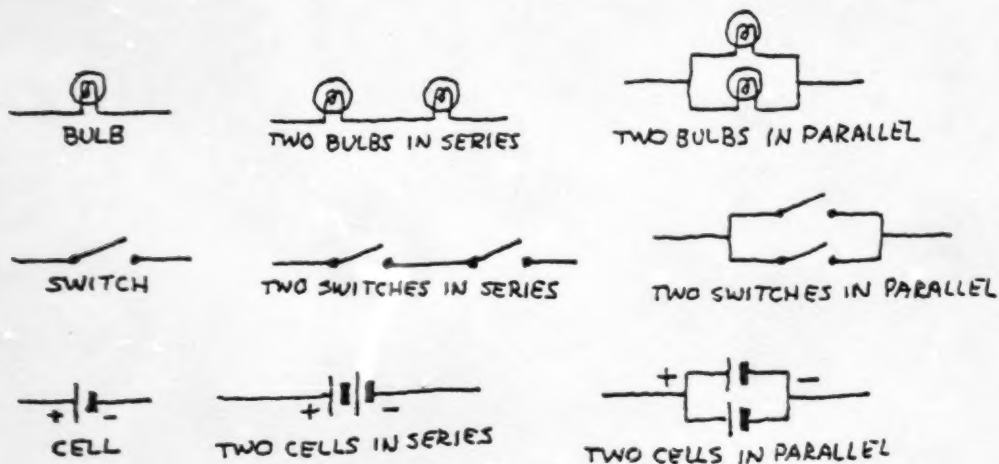
To set up several common types of circuits and study their characteristics.

Materials Required:

Wire, screwdriver, two 2.5-volt bulbs, two bulb sockets, two dry cells, two knife switches.

Information:

An electrical circuit is a conducting path through which current flows from one terminal to an electrical energy source, through one or more electrical devices, back to the other terminal of the source. Circuits may be wired in many ways. To describe a circuit, it is convenient to use symbols rather than words. The symbols together comprise what is called a "schematic". Some symbols are illustrated below:

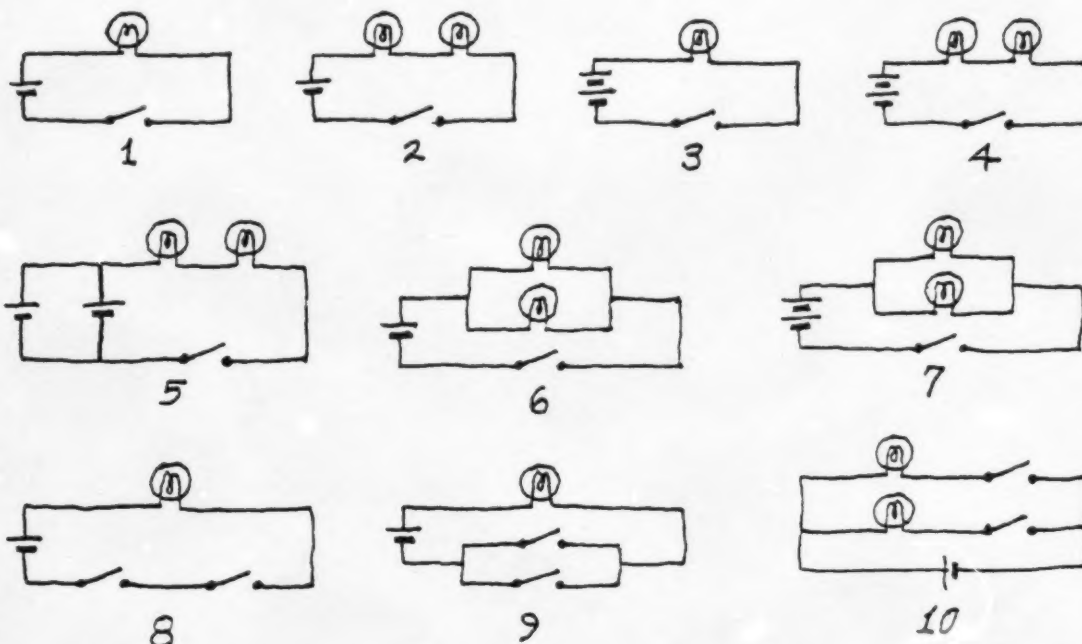


Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

In this lab exercise, you will wire each of the circuits shown in the following diagram. Observe and record what occurs when

each switch is closed and opened. Note whether the single bulb lights brightly, dimly or not at all. When two bulbs are lit, unscrew one to observe if the other is affected in any manner. Record all your observations as you go through this lab exercise.



1. Wire Circuit 1, using a bulb, switch and dry cell. Wire the cell last in the circuit. Close and open the switch. What do you observe?
2. Wire Circuit 2--two bulbs in series. With the switch closed, unscrew either bulb. What do you observe?
3. Wire Circuit 3--two cells in series. Close and open the switch. What do you observe?

Title: LAB--Electrical Circuits I

PAGE THREE

4. Wire Circuit 4--two cells in series and two bulbs in series. Close the switch and unscrew either bulb. What do you observe?

INSTRUCTOR'S INITIALS _____

5. Wire Circuit 5--two cells in parallel and two bulbs in series. Close the switch and unscrew either bulb. What do you observe?
6. Wire Circuit 6--two bulbs in parallel. Close switch and unscrew either bulb. What do you observe?
7. Wire Circuit 7--two cells in series and two bulbs in parallel. Close switch and unscrew either bulb. What do you observe?
8. Wire Circuit 8--two switches in series. Close both switches then open either one. What do you observe?
9. Wire Circuit 9--two switches in parallel. Close either switch then close both switches. What do you observe?
10. Wire Circuit 10--combination series-parallel circuit. Close either switch then both switches. What do you observe?

Title: LAB--Electrical Circuits I

PAGE FOUR

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS
PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. What advantages are there in wiring electrical devices in parallel?
2. Under what conditions would series wiring of electrical devices be desirable?
3. How should two switches be connected in a circuit so that either can control the current flow?
4. One switch in your classroom or shop may control two or more bulbs. Are these bulbs connected in series or in parallel? Explain.

Title: LAB--Electrical Circuits II

Unit: Electricity

Course: Physics

Purpose:

To draw and set up various switch and light circuits,
and to observe their characteristics.

Materials Required:

Four dry cells; three 6-volt flashlight bulbs and miniature
base sockets; two single-pole switches; two three-way switches;
wire; voltmeter.

Information:

There are many ways to wire a circuit. In this lab exercise,
you will gain some practice in wiring circuits for a specific
function. The function of the circuit will be mentioned and
you will then draw a diagram to show how this will be accom-
plished. Following this diagram, you will wire the circuit
and observe what occurs.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK
STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Complete the diagram, below, showing four cells in series.



Connect the four cells in series. Measure the terminal
voltage with the voltmeter. The voltage is _____
volts. Why are cells sometimes connected in this manner?

2. Complete the diagram, below, showing four cells in parallel.

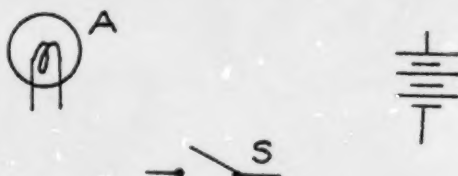


Connect the four cells in parallel. The terminal voltage
is _____ volts.

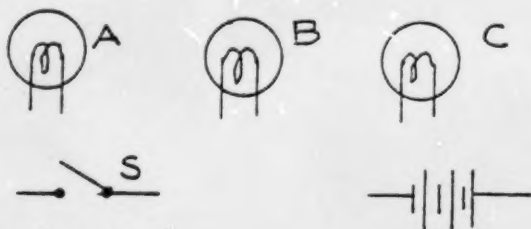
INSTRUCTOR'S INITIALS _____

NOTE: For remaining steps, cells will be connected in series.

3. Connect light A so it may be turned on or off by switch S. Draw a complete wiring diagram.

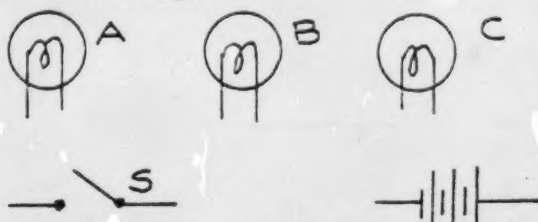


4. Connect lights A, B and C in series, controlled by switch S. Complete the diagram.



Are the lights brighter or dimmer than the one light used in Sept 3?

5. Connect lights A, B and C in parallel, controlled by switch S. Complete the diagram.



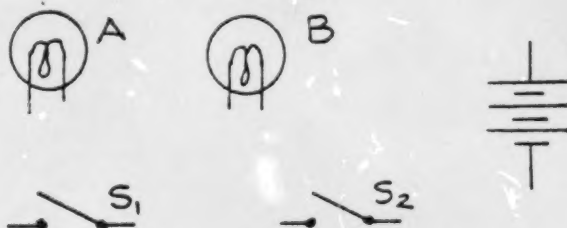
Are the lights brighter or dimmer than the lights in Step 4?

Which circuit, this one or the one in Step 4, is using more electric power? Explain.

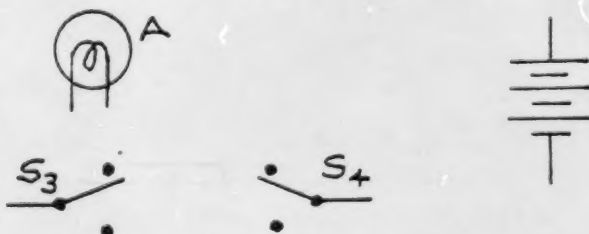
Are electric lights in your home connected in series or parallel? Explain.

INSTRUCTOR'S INITIALS _____

6. Connect lights A and B so that switch S_1 will control light A and switch S_2 will control light B. Complete the diagram.



7. Connect light A so it can be turned on or off by either three-way switch S_3 or S_4 . Complete the diagram.



Why are three-way switches used? Explain.

Name some places in your school or home where three-way switches are used or could be used. Explain why.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Ohm's Law

Unit: Electricity

Course: Physics

Purpose:

To apply Ohm's Law to calculate resistance.

Materials Required:

DC current source (1.5 to 8 volts); voltmeter (0-15 volts);
ammeter (dual 0-1.5 and 0-15 amps); 5-watt resistors (5, 10 and
15 ohms); wire; knife switch.

Information:

In a DC circuit, the current depends on two factors. The two factors are the electromotive force (or voltage) which pushes the electrons through the circuit, and the resistance the circuit offers to the flow of these electrons.

In 1827, George Ohm first stated the relationship between current, electromotive force (voltage), and resistance in a circuit of metallic conductors. Ohm's Law states that if the temperature of the resistance remains constant, the electric current (I) flowing in a circuit is directly proportional to the applied voltage (E) and inversely proportional to the resistance (R) of the circuit:

$$I = \frac{E}{R}$$

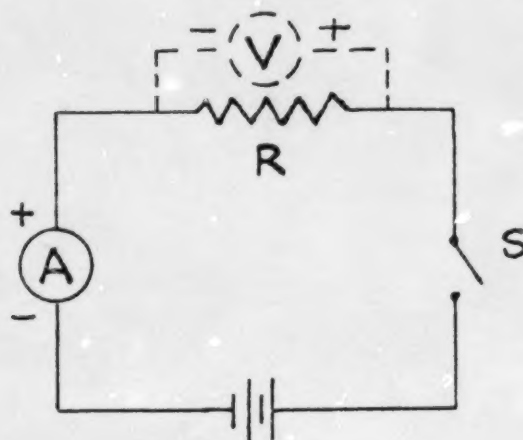
Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Study the scales on the voltmeter and ammeter and be certain that you can read them properly.
2. Wire the circuit shown in the diagram below. LEAVE THE KNIFE SWITCH OPEN UNTIL THE CIRCUIT IS CHECKED BY YOUR INSTRUCTOR. Use the 5-ohm resistance. Note that the ammeter is placed in series in the circuit and that the voltmeter is placed in parallel across the resistance. Set voltage at 1.5 or 3 volts.

(Diagram on Page Two)

PAGE TWO



INSTRUCTOR'S INITIALS _____

3. After your instructor has approved your circuit, close the circuit and QUICKLY read the meters. Open the switch as soon as readings are completed. Record readings in table.
4. Using Ohm's Law, calculate the value of the resistor in ohms. Record your answer in the table, show your work below:

INSTRUCTOR'S INITIALS _____

5. Increase the voltage to 6 or 8 volts and again read the meters. Record the readings in the table and calculate the resistance via Ohm's Law.
6. Repeat the above steps, with the 10-ohm and then the 15-ohm resistor. Start with the lower voltage, then change to the higher voltage. Record all data in the table.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

TRIAL	KNOWN RESISTOR VALUE	VOLTAGE (E) volts	CURRENT (I) amperes	RESISTANCE ($R = \frac{E}{I}$) ohms
1	5 Ω			
2	5 Ω			
3	10 Ω			
4	10 Ω			
5	15 Ω			
6	15 Ω			

Questions:

1. What happens to the current flow in a circuit when the resistance is increased?
2. What happens to the current flow in a circuit when the voltage is increased?
3. Explain how the voltmeter and ammeter are connected in a circuit?

Title: LAB--Ohm's Law

INSTRUCTOR'S NOTES

Prior to lab, review the proper methods for connecting and reading the meters.

Be certain to check each circuit before it is energized. Better lab management will occur if the students are indoctrinated to the fact that no circuits are energized unless first checked by you.

If you do not have any resistors, various lengths of wire may be used.

COMMENTS:

Title: LAB--Series Circuits I

Unit: Electricity

Course: Physics

Purpose:

To develop an understanding of series circuits.

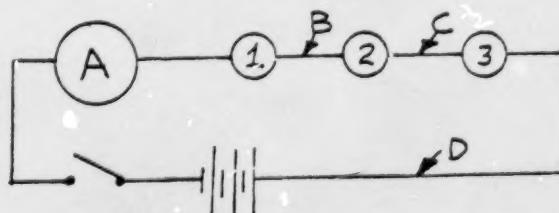
Materials Required:

6-volt storage battery; three 2-volt miniature lamps and sockets; knife switch; ammeter; voltmeter with flexible leads; wire.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Connect battery, 2-volt lamps, switch and ammeter as shown in the diagram below.



2. Note the reading of the ammeter before switch is closed.
3. Close switch, lighting the lamps, and read ammeter. Repeat with ammeter at B, C, D.
4. Connect flexible leads of voltmeter to read the voltage across the battery, each lamp and the ammeter.
5. Record readings below:

Voltage across battery	_____
Lamp 1	_____
Lamp 2	_____
Lamp 3	_____
Amperage at A (open)	_____
A (closed)	_____
B	_____
C	_____
D	_____

CLEAN UP YOUR WORK STATION. BE CERTAIN TO PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Series Circuits I

PAGE TWO

Conclusions:

1. Before the switch is closed, what does the ammeter read?
What kind of circuit is this called?
2. When the switch is closed, what kind of circuit is this called?
3. What is the method of connecting the lamps in this lab exercise called?
4. How does the voltage across the battery compare with the sum of the voltages across lamps 1, 2, and 3?
5. How do the ammeter readings at A, B, C and D compare?

Title: LAB--Series Circuits II

Unit: Electricity

Course: Physics

Purpose:

To determine how resistances combine when connected in series.

Materials Required:

DC current source; voltmeter (0-15 volts); ammeter (0-1.5 amps); three 10-ohm resistors; wire; knife switch.

Information:

A series circuit consists of resistors (in this exercise) connected in series with a source in such a manner that the current must flow through each resistor in turn. The total resistance of a series circuit is equal to the sum of the resistance of the individual resistors in the circuit.

$$R_t = R_1 + R_2 + R_3$$

Since the series circuit can be thought of as a single loop, it follows that the flow of electrons must be the same at any point in the circuit.

I is constant

If the resistance is considered to be something that must be overcome by a force, as each resistance is overcome some force (or voltage) is lost. The voltage lost by resistance in a circuit is called VOLTAGE DROP or IR DROP (from Ohm's Law $E = IR$). The sum of the voltage drops in a series circuit is equal to the applied voltage.

$$E_t = E_1 + E_2 + E_3 \dots$$

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Wire a single resistor in series with the ammeter, switch and power source. REMEMBER TO LEAVE SWITCH OPEN UNTIL YOUR CIRCUIT HAS BEEN CHECKED BY YOUR INSTRUCTOR. Set voltage at about 6 volts. Connect voltmeter in parallel with the resistor.

INSTRUCTOR'S INITIALS _____

2. Close the switch and read the meters. Open switch as soon as meter readings are completed.

Known value of resistor = _____ ohms.

Ammeter reading = _____ amperes.

Voltmeter reading = _____ volts.

Calculated resistance ($R = E/I$) = _____ ohms.

3. Arrange two resistors in series with each other and connect in series with the other parts of the circuit. Voltage should still be set at about 6 volts. The voltmeter is connected in parallel across both resistors.

INSTRUCTOR'S INITIALS _____

4. Close switch and make necessary meter readings. Open switch.

Known value of each resistor = _____ ohms and _____ ohms.

Sum of known values = _____ ohms.

Ammeter reading = _____ amperes.

Voltmeter reading = _____ volts.

Calculated resistance = _____ ohms.

5. Arrange three resistors in series with each other and connect in series with the other parts of the circuit. Voltage is set at about 6 volts. The voltmeter is connected in parallel across all three resistors.

INSTRUCTOR'S INITIALS _____

6. Close switch, make necessary meter readings, open switch.

Known value of each resistor = _____ ohms, _____ ohms
and _____ ohms.

Sum of known values = _____ ohms.

Ammeter reading = _____ amperes.

Voltmeter reading = _____ volts.

Calculated resistance = _____ ohms.

7. Keeping the three resistors in series, measure the voltage drop across each resistor with the voltmeter. Place the voltmeter across each resistor, in turn, close the switch and take the meter reading. Then place the voltmeter across all three resistors.

Title: LAB--Series Circuit II

PAGE THREE

Voltage drop E_1 = _____ volts

Voltage drop E_2 = _____ volts

Voltage drop E_3 = _____ volts

Total voltage drop $E_1 + E_2 + E_3$ = _____ volts

Voltmeter reading across all three resistors = _____ volts

Compare the data that you secured in this lab exercise.
What conclusions do you draw?

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED
AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Series Circuits II

INSTRUCTOR'S NOTES

Remind students to check polarity to their meters before energizing their circuits.

Three 5-ohm resistors may be used in place of the 10-ohm resistors. In fact, any low value resistors may be used provided that they are compatible with the meters being used.

COMMENTS:

Title: LAB--Parallel Circuits I

Unit: Electricity

Course: Physics

Purpose:

To develop an understanding of parallel circuits.

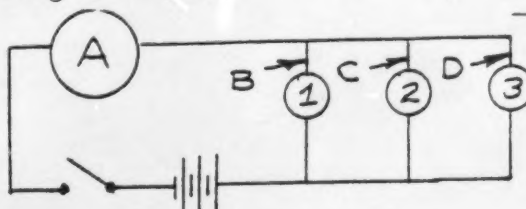
Materials Required:

6-volt storage battery; three 6-volt miniature lamps and sockets; knife switch; ammeter; voltmeter with flexible leads; wire.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Connect the battery, 6-volt lamps, switch and ammeter as shown in the diagram below.



2. Read the ammeter before closing the switch.
3. Close the switch and read the ammeter. Repeat with the ammeter at B, C and D.
4. Take voltage readings across the battery, each lamp and the ammeter.
5. Record readings below.

Voltage across battery	_____
lamp 1	_____
lamp 2	_____
lamp 3	_____
ammeter	_____
Amperage at A (open)	_____
A (closed)	_____
B	_____
C	_____
D	_____

Title: LAB--Parallel Circuits I

PAGE TWO

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Conclusions:

1. What method of connecting lamps is used in this lab exercise?
2. How does the voltage across the battery compare with the sum of the voltages across the lamps 1, 2 and 3?
3. How does the voltage across each lamp compare with the voltage across the battery?
4. How do the ammeter readings at B, C and D compare?
5. How does the ammeter reading at A compare with the sum of the ammeter readings at B, C and D?

Title: LAB--Parallel Circuits II

Unit: Electricity

Course: Physics

Purpose:

To determine how resistances combine when connected in parallel.

Materials Required:

DC current source; voltmeter (0-15 volts); ammeter (0-15, 0-1.5 ampere); three 30-ohm resistors; wire; knife switch.

Information:

When resistors are connected in parallel, each resistor provides a path for current flow and, therefore, reduces the total resistance to the current. Each time a resistance is connected in parallel with other resistors, the total resistance decreases.

$$\frac{1}{R_t} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

The voltage across all branches of paths of a parallel circuit is the same. In the case of a straight parallel circuit, it is the same as the applied voltage.

E is constant

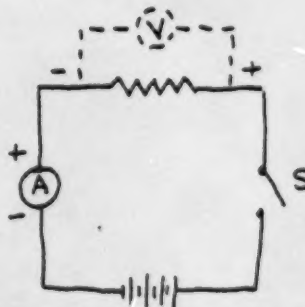
The total current in the circuit is equal to the sum of all the currents flowing in the branches of the parallel circuit.

$$I_t = I_1 + I_2 + I_3 \dots$$

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Wire the circuit indicated in the sketch below. Close the switch and make the necessary meter readings. Record the data in the spaces provided.



PAGE TWO

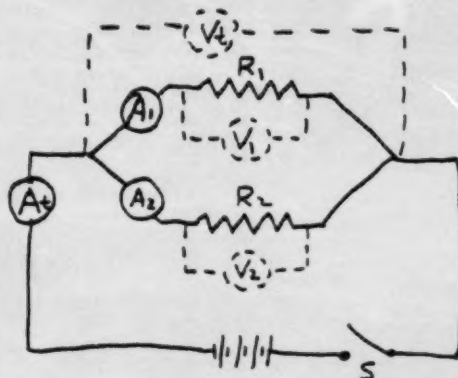
Known value of resistor = _____ ohms.

Voltmeter reading = _____ volts.

Ammeter reading = _____ amperes.

Calculated resistance ($R = E/I$) = _____ ohms.

2. Wire the circuit indicated in the sketch below. Before you close the switch have the circuit checked by your instructor.



INSTRUCTOR'S INITIALS _____.

Close switch, make necessary meter readings, record data in space provided.

Known value of resistors = _____ ohms and _____ ohms.

Total resistance of known resistors (Remember: they are connected in parallel) = _____ ohms.

Voltmeter reading V_c = _____ volts.

Ammeter reading A_c = _____ amperes.

Calculated total resistance ($R = E/I$) = _____ ohms.

Voltmeter reading V_1 = _____ volts.

Ammeter reading A_1 = _____ amperes.

Calculated resistance R_1 = _____ ohms.

Voltmeter reading V_2 = _____ volts.

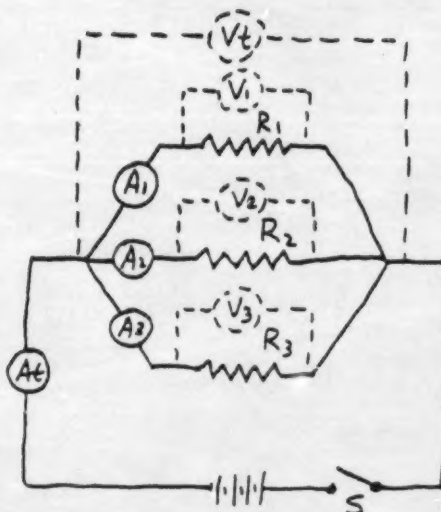
Ammeter reading A_2 = _____ amperes.

Calculated resistance R_2 = _____ ohms.

Sum of currents A_1 and A_2 = _____ amperes.

Calculated total resistance (R_1 and R_2 in parallel) _____ ohms.

3. Wire the circuit indicated in the sketch below, and have it checked by your instructor.



INSTRUCTOR'S INITIALS _____,

Close switch and make the necessary meter readings. Record data and make necessary calculations.

Ammeter readings $A_t =$ _____, $A_1 =$ _____,

$A_2 =$ _____ and $A_3 =$ _____.

Voltmeter readings $V_t =$ _____, $V_1 =$ _____

$V_2 =$ _____ and $V_3 =$ _____.

Calculated total resistance ($R_t = V_t/A_t$) = _____.

Calculated total resistance (based on known values of resistors) = _____ ohms.

Calculated resistance of each branch (e.g. $R_1 = V_1/A_1$)

$R_1 =$ _____, $R_2 =$ _____ and $R_3 =$ _____.

4. Based on what you observed and/or calculated during this lab exercise, what generalizations can you make concerning parallel circuits?

CLEAN UP YOUR WORK STATION. PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____.

Title: LAB--Parallel Circuits II

INSTRUCTOR'S NOTES

Three 10-ohm or three 15-ohm resistors may be substituted for the 30-ohm resistors.

If enough meters are available, you may issue enough so that each circuit (complete with meters) can be wired. If there are not enough, the student will simply have to shift the meter to take a new reading. Keep in mind that this will increase the time it takes to complete the lab.

COMMENTS:

Title: LAB--Series-Parallel Circuits

Unit: Electricity

Course: Physics

Purpose:

To determine how resistances combine in a series-parallel circuit.

Materials Required:

DC current source; voltmeter (0-15 volts); ammeter (0-15, 0-1.5 amperes); three 10-ohm resistors; wire; knife switch.

Information:

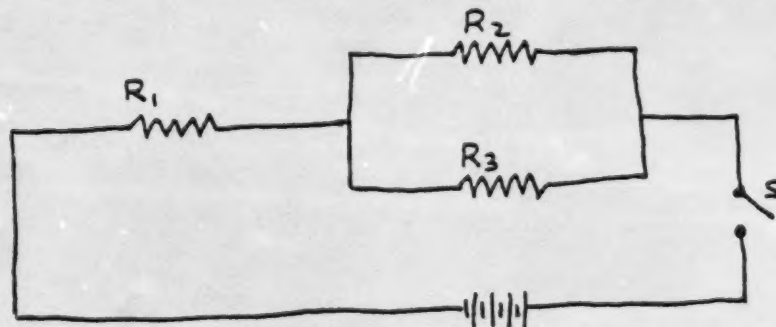
In previous lab exercises, you gained experience in, what might be called, straight series and straight parallel circuits. In this lab, you will study a combination series-parallel circuit. This type of circuit is often used when it is necessary to reduce the current flow into the parallel portion of the circuit. The resistor in series with the parallel branches increases the total resistance and, thereby, reduces the current available to the parallel branches of the circuit.

To find the total resistance of the circuit, the parallel branches are reduced to a single resistance first. Then the circuit is treated as a simple series circuit.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Wire the circuit indicated in the sketch below. On the sketch show where you would place the voltmeter and ammeter to get the necessary measurements. DO NOT CLOSE THE SWITCH OR PROCEED UNTIL YOUR INSTRUCTOR HAS CHECKED YOUR WORK.



INSTRUCTOR'S INITIALS _____

2. Calculate the resistance of the circuit, using the known values of the resistors. Find the equivalent resistance of R_2 and R_3 in parallel. Then find the resistance of R_1 and R_{2-3} in series. Show your calculations below.

3. Close the switch and make the necessary meter readings. Record the readings in the space below.

4. Using your meter readings (along with your experience gained in previous labs) and Ohm's Law, calculate the total resistance for the circuit. Show wll work below.

How does the calculated circuit resistance based on known values for the resistors compare to that calculated from your meter readings? Explain

CLEAN UP YOUR WORK STATION. PLACE ALL EQUIPMENT AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Title: LAB--Series-Parallel Circuits

INSTRUCTOR'S NOTES

It is obvious that many details in the "Procedure" for this lab exercise have been omitted. The reasons are many, but a few are:

To get the student to use what was learned in previous labs (where to take meter readings, what readings are needed to make calculations, etc.).

To determine how far the student has advanced in working with circuits.

To get the student to think on his/her own.

COMMENTS:

Title: LAB--Overloaded Circuits

Unit: Electricity

Course: Physics

Purpose:

To obtain an understanding of the heating effect of an overload and how simple circuits are protected against this overload.

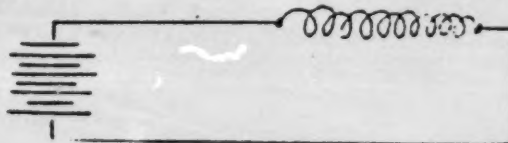
Materials Required:

Storage battery; #28 B & S insulated copper wire; fuse and fuse block; #14 B & S wire - 2 ft. or 3 ft. lengths.

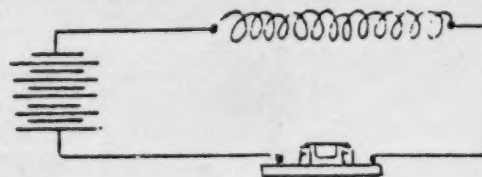
Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

1. Coil about 3 1/2 ft of #28 B & S wire around a pencil and connect between binding posts of a battery as shown.



2. Touch wire A to end of coil for a few seconds. Carefully touch the coil with your hand and note any change in temperature.
3. Touch wire A again to end of coil and keep connected for 1/2 minute.
4. Connect apparatus as shown below, inserting fuse block, again leaving lead A off until ready.



5. Touch lead A to end of coil and leave connected.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Title: LAB--Overloaded Circuits

PAGE TWO

Conclusions:

1. What happened to the coiled wire when lead wire A was connected momentarily to end of coil?
2. What happened to coiled wire when the connection was left on?
3. What happened to the coiled wire when the connection was left on with the fuse block in the circuit?
4. What happened to the fuse?
5. Does the metal in the fuse have a lower or higher melting point than the copper wire?
6. If the coiled wire was part of the wiring of a house and there wasn't a proper fuse in the circuit, what probably would happen?

Title: LAB--The Transformer

Unit: Electricity

Course: Physics

Purpose:

To study the principle of the transformer.

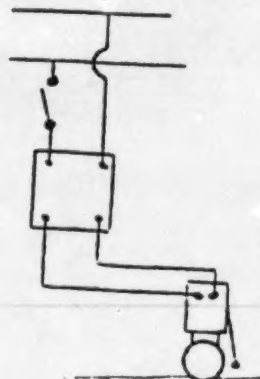
Materials Required:

AC power source; storage battery; induction coil and spark plug; electric bell with a transformer; demonstration transformer with coils; AC voltmeter 15-150 scales.

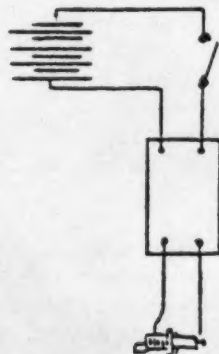
Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

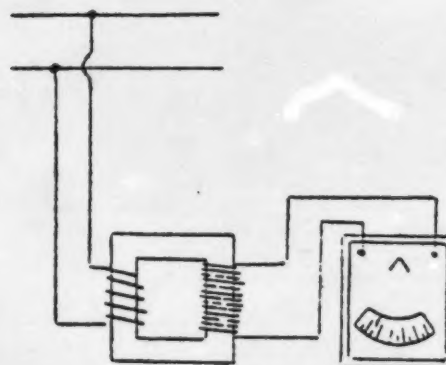
1. Connect bell and transformer to 110 v, A.C. line as shown:



2. With A.C. voltmeter check the voltage across the primary and secondary of the transformer.
3. Connect battery to a spark plug. Close and open battery connection several times. Set up battery, spark coil and spark plug as shown. Close and open battery connection several times and note what happens.



4. Set up demonstration transformer as shown, using different combinations of coils as provided, in turn checking the voltage each time a coil is changed.



		VOLTAGE ACROSS PRIMARY	VOLTAGE ACROSS SECONDARY
BELL-RINGING TRANSFORMER			
DEMONSTRATION TRANSFORMER	1 ST COMBINATION		
	2 ND COMBINATION		
	3 RD COMBINATION		
	4 TH COMBINATION		
	5 TH COMBINATION		

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR. INSTRUCTOR'S INITIALS _____

Conclusions

1. Refer to the primary and secondary voltage readings in each case and state what you think is the purpose of a transformer.
2. From observing the action of the induction coil and plug state whether or not there is a difference between the primary and secondary voltage.
3. From the voltage readings in the table on the demonstration transformer and the number of turns on the primary and secondary in each case state the relation between the primary and the secondary voltage and the turns on the primary and the secondary coils.

Title: LAB--Making an Ammeter

Unit: Electricity

Course: Physics

Purpose:

To show the principle parts of an ammeter and how it works.

Materials Required:

U-shaped magnet; Heavy copper wire; Large paper clips;
2 Large sewing needles, 2-1/2"; Cardboard strip; tape.

Procedure:

FOLLOW ALL DIRECTIONS CAREFULLY. DO YOUR OWN WORK. KEEP WORK STATION CLEAN AND IN ORDER. PRACTICE SAFETY AT ALL TIMES.

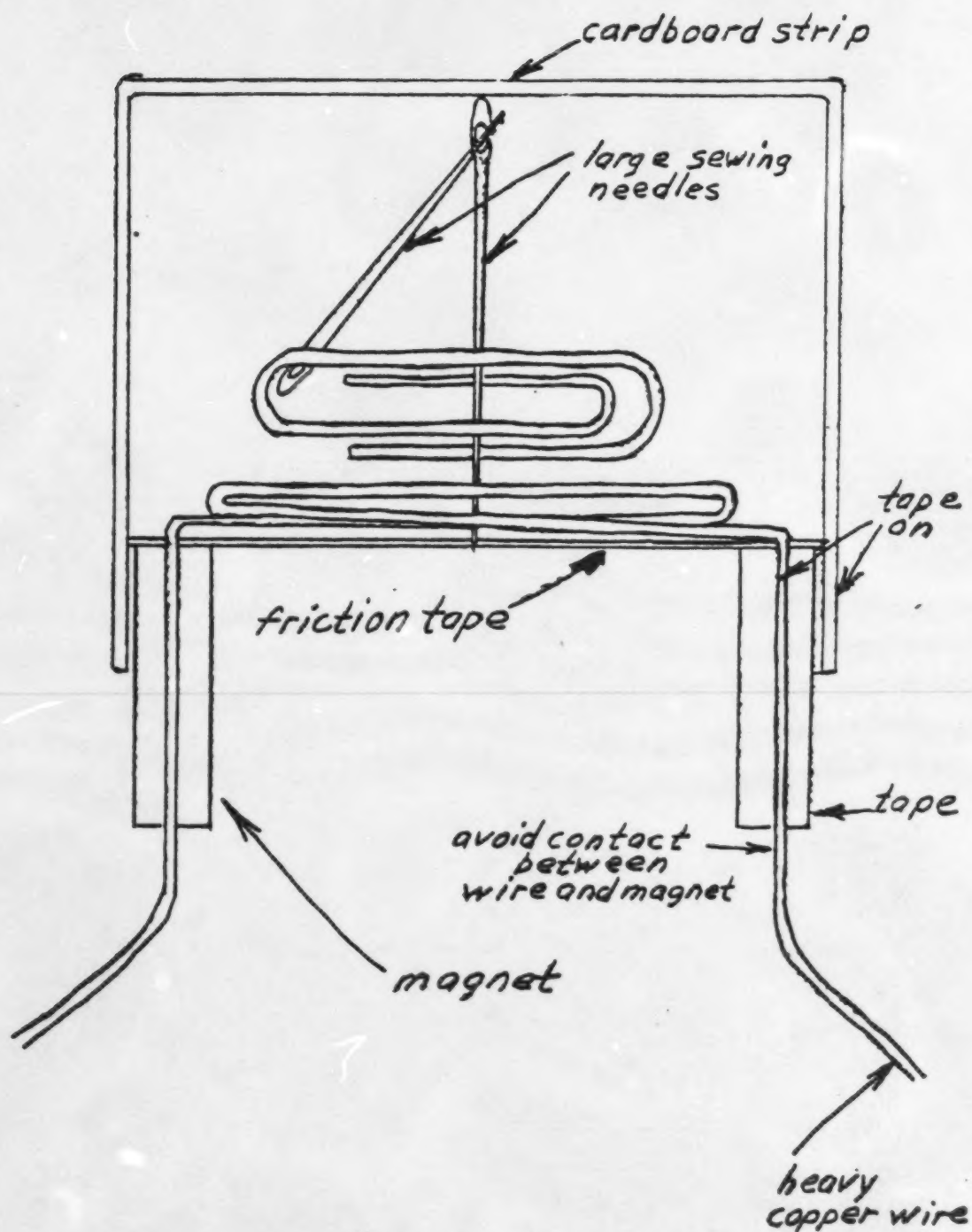
1. Tape over ends of magnet, two inches down its sides. Make a coil in the wire and tape it to the magnet.
2. Cut a cardboard strip. Tape the cardboard to the magnet.
3. Place the paper clips on the needle. Put the needle through the hole of the other needle as shown in sketch.
4. Put assembled needle between the tape and the cardboard. Place magnet on edge of desk with pointer needle hanging down.
5. Connect in circuit correctly.

CLEAN UP YOUR WORK STATION. BE CERTAIN THAT ALL EQUIPMENT IS PLACED AS DIRECTED BY YOUR INSTRUCTOR.

INSTRUCTOR'S INITIALS _____

Questions:

1. Explain why the needle is deflected when current flows through the wire.
2. Explain why there is more deflection with more current.
3. Of what material must the paper clip be? Why?
4. Explain what effect more coils of the heavy copper wire would make.
5. Explain what effect much friction on the ends of the needle would have.
6. Explain why reversing the current changes the direction of the needle.



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